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FACTORY LABOR MANAGEMENT IN CHINA

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S U M M A R Y   O F   C O N T E N T S

Factory Labor Management in China

This publication gives in full Chapters 3, 4, and 5 of Kung-chang Lao-tung Ching-chi (Factory Labor Economics), by Chu Tzu-shou, published by the Li-hsin Hui-chi T'u-shu Yung-p'in-she, Shanghai, 1951.

Topics discussed include labor efficiency, labor safety and welfare measures, labor productivity, and wages and hours in factories. Detailed treatment of these problems from the approach of labor management is presented together with the application of some of the principles of labor management practiced in the Soviet Union.

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FACTORY LABOR MANAGEMENT IN CHINA

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Part 1. LABOR EFFICIENCY

I. WORKING CONDITIONS

Favorable working conditions are a prerequisite of high labor efficiency. The following is a discussion of the various factors that determine labor efficiency.

A. Temperature and Relative Humidity

Body temperature and atmospheric temperature directly affect the utilization of our energy. Through a delicate mechanism, the body maintains a temperature of 37 degrees [centigrade]. Atmospheric temperature affects efficiency by affecting body temperature.

Several environmental conditions such as the amount of factory space per worker and impurities in the air exercise considerable influence on labor efficiency. Several additional factors can affect efficiency through their effect on body temperature. Generally speaking, (1) a low temperature is better than a high temperature; (2) dry air is better than humid air; and (3) air circulating throughout the room is better than air which does not circulate. In other words, the temperature, humidity, and circulation of the air in a workshop determine body temperature, thereby affecting labor efficiency.

Ventilation has a great effect on human health and labor efficiency. Insufficient ventilation causes fatigue, even if the working space is large. There must be an equilibrium between the heat lost and the heat generated by the human body to maintain a constant body temperature. Such an equilibrium is upset when air circulation is inadequate. It is of special importance to maintain a constant temperature for work in high or low temperatures or work involving physical exertion.

Environmental factors affecting labor efficiency in a manufacturing plant include the temperature, humidity, and circulation of the air and the temperature of the building and equipment. The body reacts to humidity more sensitively at high temperature, as in summer, than at a low temperature. The effect of high temperature on the human body is well known. For instance, the labor efficiency is low in a plant using furnaces which radiate great heat and make the workers uncomfortably hot.

Ventilation is very important when working under high temperatures. The circulation of air aids the evaporation of perspiration and accelerates the lowering of body temperature. Perspiration is annoying when the temperature is high, the air humid, and ventilation insufficient. Under such conditions one is likely to feel stuffy, uncomfortable, wet, and fatigued, and to work less efficiently.

Since human physiological reactions vary with the intensity of physical exertion and the nature of work, the optimum environmental conditions of temperature, humidity, and air circulation also vary. Numerous studies have been made of the relationship between environmental conditions and labor efficiency. The following is a summary of published reports. Environmental conditions are measured by a simple unit such as a dry-bulb thermometer on by a multiple unit such as the dial thermometer.

The following table shows the maximum temperatures for various types of work. These types of work can be done at temperatures lower than those listed in the table, but work efficiency diminishes when the temperature exceeds the limits, which may therefore be called safety limits. To continue working at a higher temperature results in low efficiency and ill health.

Temperature Limits for Various Types of Work

Type of Work	Dry-Bulb Temperature (°C)	Wet-Bulb Temperature (°C)	Dial-Type Thermometer (°F)
Mental work	27	24	73-90
Light physical work	27.5	21-24	71-80
Strenuous physical work	21-35	27-30	60-87
Mining	36.9	-	79

B. Adequate Lighting

Inadequate lighting can cause great losses, for it contributes to accidents and waste, diminishes work efficiency, and makes workers uncomfortable.

Modern factories utilize sunlight as much as possible, and some even have glass walls to obtain the greatest amount of sunlight. Ground glass, which diffuses the light towards the floor, is widely used by modern factories to produce an even distribution of light.

Although natural light is often adequate for working, we cannot do without artificial light, since on a seasonal average 15-20 percent of the time in a day is without sufficient sunlight. Lighting is therefore a crucial problem for modern industry.

Not only must sufficient light be provided but it must be distributed evenly. Diffused lighting avoids full or partial reflection of light from objects. It is not feasible to install light bulbs only on the machines, for a sudden change from darkness to light (when the lights are turned on) affects the eyes and nervous system, and causes fatigue. Thus, a ceiling light which evenly illuminates the whole machine is better than a light installed on the machine itself. If it is necessary to illuminate the machine, only a low-wattage and frosted light bulb should be used.

According to optical studies, industrial lighting must meet the following three standards:

1. There should be a proper amount of light. Weak light not only damages human eyes but also contributes to accidents. Generally, products of night work are inferior to those of day work. Strong light is also harmful to the eyes. In short, light stronger or weaker than a certain standard is harmful to the eyes and diminishes efficiency.

The following factors should be considered in industrial lighting:

(a) Speed of perception -- This refers to the ease with which an object is distinguished. Experiments have shown that the speed of perception increases as the intensity of illumination increases. Generally speaking, the speed of perception at 90 luxes is five times greater than that at 5 luxes. (One lux is the intensity of illumination on a surface one meter from a light source equal to .1 candle power.

(b) Sharpness -- Two points at an equal distance from the light source must bear a clear contrast. The sharpness of illumination of a light source does not increase in direct proportion with the intensity of illumination. Generally speaking, the intensity of illumination in an industrial plant must not be lower than 40 luxes.

(c) Optical adaptability -- An adequate lighting system should enable the workers to distinguish objects on different levels and under different light sources. This adaptability varies with the amount of illumination. Adequate illumination is obtained when the basic lighting is 5 luxes per light source and when there are 60 luxes.

An illumination of 100 luxes is sufficient for a machine shop and one of 60 luxes for an office or store. The brightness of such a lighting system should be equal to the minimum brightness provided by natural light. An industrial plant must maintain this minimum brightness.

2. Light should be evenly distributed and should be of constant intensity. A light source which changes suddenly in brightness causes the iris to expand or contract and creates fatigue. One should thus avoid sudden darkness or light. Direct lighting has recently been replaced by diffused lighting. If possible, a large lamp should be used to light the entire room.

Lighting equipment is of several types: (a) semidirect, which illuminates a designated area, part of the illumination going to the ceiling and producing a reflection from there; (b) semi-indirect, which uses opal glass as a reflector and thus produces an evenly diffused light; (c) indirect, which produces a reflected light from the ceiling or walls, is hidden in the walls, and does not cause eye fatigue.

3. Glare should be eliminated. It is produced by direct lighting, by reflection from glass, or by the incidental light from moving objects. Glare can be avoided by using of indirect lighting.

C. Sound and Rhythm

The relation of sound to work can be seen from two facts: (a) work requiring concentration must be performed in a quiet place, and (b) performance of strenuous physical work is aided by accompaniment of rhythmical sound. Thus, the planning division and the executive office of a plant should be located away from the workshop so that machine noise cannot be heard. Mental effort has to be doubled while working in a noisy place. In a modern plant, the typists, bookkeepers, and stenographers work in separate rooms away from other workers. Efforts is also made to reduce the noise from typewriters and adding machines. According to experts, work efficiency in a quiet place is 15 percent higher than in a noisy place.

Strenuous physical work should be performed in a place where there is rhythmical sound. Rhythmical sound helps to minimize fatigue. The singing or broadcasting of popular songs can diminish fatigue and is therefore recommended by experts in management.

Discordant sounds often cause low efficiency. In fact, thunder storms and lightning have sometimes created accidents and caused damage to machines and resulted in qualitative deterioration in a plant.

D. Color

Color harmony, the effect of color on the nervous system, and the reflection ratio of various colors are important in the science of industrial management. A workshop should decorate its walls with beautiful wallpaper and ornamental glass and paint its machines and tools in light colors so that the workers will feel relaxed.

Colors have different reflection ratios. White has a maximum reflection ratio of 80 percent, while dark green has a reflection ratio of only 10 percent. In the past, people paid little attention to the painting of the walls, considering it an insignificant matter. Properly painted walls provide a pleasant atmosphere and are conducive to high efficiency. In outdated plants, the walls and ceilings are dirty, painting them white would improve the illumination. Modern industrial plants often paint the workshops in various colors designed to convey feelings of warmth, coolness, etc. to the workers. Although a workshop may have many windows and enough light, its walls should be painted to produce the proper lighting effect. A proper lighting system together with harmonious colors can make the workers feel comfortable, enable them to see the machines and tools easily, and thereby improve their efficiency. A proper amount of light can be obtained from sunlight and by having clean white walls and ceilings.

Modern factories use mostly white or very light colors on their walls. Ceilings are painted white or greyish white. Offices are painted greyish white, light yellow, light green, or gray. Paints are usually mixed with linseed oil before application, because they become yellowish when dry and produce less glare. Now a new paint, known as factory-white paint, is in use which helps to improve the lighting of the workshops and never turns yellow.

The color of the machines and tools can also affect the mental and physical health of the workers. The color of the machines and that of their products should be distinctly different in hue and intensity. It is generally believed that machines painted green help to diminish fatigue and improve efficiency.

E. Plant Layout

Plant layout should be based on a careful study of the capacity of the machines, the space each machine occupies, and operational details. Each arrangement in the over-all layout or in such details as the location of worktables or desks must accord with the needs of the operations and the workers. The location of raw materials, the internal transportation system, and the disposal of finished products all affect labor efficiency. A poor layout system irritates the workers and thus lowers their morale. By improving its layout, an old factory can save a great amount of time and energy.

The method of conveying raw materials and the machine arrangement inside the plant may seem to have nothing to do with work efficiency. But a careful examination will show that efficiency depends largely on the organization of operations. For instance, if the raw materials are supplied to the workshops, in the right quantities and at the right time, operation can be continuous. On the other hand, if the supply of raw materials does not keep pace with the workshop operations, workers will be idle and waste will result. Finished products should be removed from the workshops and shipped to the market as soon as possible so that the factory will not become congested and capital will not be tied up. A mechanical internal transportation system, often used by large factories, is efficient and facilitates coordination of work.

II. STUDY OF WORKING TIME

The length of working time affects labor efficiency closely. The matter of the proper number of work hours for each industry to achieve maximum labor efficiency should be carefully studied. This matter is complicated, since it involves not only industrial management, but also economics, physiology, and psychology.

The labor problem which has existed since the growth of capitalism, involves unemployment, wages, and working hours. Unemployment and wage problems no longer exist in a socialist country. Nevertheless, the problem of working hours is still outstanding since, from the viewpoint of theory, a proper amount of working time is essential for improving labor efficiency.

Generally, the decrease of absolute working hours (per month or week; for example, a 50-hour week is changed to a 40-hour week) can raise labor efficiency to a certain limit, after which a further reduction tends to decrease efficiency. Furthermore, the relation between working hours and efficiency does not follow a fixed pattern or rule. It varies with the nature of the industry and the physiological and phychological conditions of the workers. In short, the problem of working hours is complicated and should be further studied by scholars and experts in industrial management.

If the era before the industrial revolution is a handicraft era, the era after the industrial revolution is a factory era. The working-hours problem has become a focus of attention in the period after the industrial revolution. In the age of handicrafts, men worked from daybreak to sunset. The problem of working hours was insignificant. Under the factory production system, in which machines are used, the working hours can be prolonged. In fact, to earn more profits, the capitalists lengthened the working hours. Working hours in the handicraft and family industries were also prolonged to meet the competition from modern industry. In Great Britain, the working time for a manufacturing plant was 16 hours. As a result of the subsequent development of the chemical industry and the demand for continuous operations, working time was reduced to 12 hours per day. The 12-hour day was introduced in many countries as the industrial revolution spread. As a result of labor legislatión and of the increased cultural level of the workers, the working time tends to decrease.

A new theory of the relation between working hours and efficiency was developed by a German professor named Brentano. In the late 19th Century, he gathered considerable data to prove the advantages of a shorter working day. He also directed the interest of many scholars to the working-time problem. Subsequently, many studies were made by these scholars. To avoid production surpluses, the capitalists as a rule shortened the working day. But this did not bring about a corresponding decrease in production. Thus, a shorter work day does not mean a smaller output. However, Brentano did not explain the impact of a longer or a shorter working day or which is desirable from the viewpoint of workers on the same cultural level, with the same living standards, under the same management. and with the same technical skill.

A more comprehensive study of the relation between working hours and labor efficiency was made by Abbe. Utilizing his experience in factory management, he pointed out the characteristics of labor common to all industries. According to Abbe, the division of labor which formed the basis for the technical progress of the 19th Century requires repetitive or monotonous movement, or that which utilizes the same muscles and nerves, with the same posture. Since the movement is monotonous, the worker depends on rest and nutrition to recover from fatigue. If he cannot recover his lost energy even slightly, his capacity to work diminishes. Abbe also concluded that a worker's efficiency may increase for a short time (e.g., a week) after he receives a bonus for extra work. But his efficiency tends gradually to decrease and returns to its previous level in the third or fourth week after he receives the bonus.

Long working hours undoubtedly diminish efficiency. During World War I, the Allies greatly lengthened working hours to increase the production of ammunition. Efficiency dropped considerably (by about 68 percent) after working hours were extended beyond 70 hours per week. Subsequently, working hours were reduced by 20 hours, and efficiency increased.

Does a shorter working day increase efficiency? O. Lipmann presented a formula for computing the so-called optimum working day. The proper number of working hours per day depends to certain extent on the health of the individual workers, the nature of the industry, and the types of assignment. According to Lipmann, the maximum working day is 6 hours for glass and porcelain workers and 7.5 hours for toolmakers. After factual investigation, C. H. Miles and A. Angels concluded that labor efficiency gradually increases as the work week decreases from 48 hours to 40 hours, but decreases as the work week decreases from 40 hours to 36 hours. Generally, a 40-hour week is best. This means that the work day (on a 6-day week basis) is less than 7 hours. The disadvantage of a short work day is that it does not allow sufficient time for the workers to acquire skills, in other words, they leave work before their skills reach a peak. The result is that efficiency will not reach a high level. Thus, a proper number of working hours is essential for high efficiency.

Proper rest is also indispensable for increased efficiency. This too is a complex problem. The length and frequency of rest periods and the method of relaxation need to be determined by actual circumstances. According to H. Manzer, a worker can recover from his fatigue by 82 percent after 5 minutes of rest, 90 percent after 10 minutes, and 95 percent after 20 minutes. A complete recovery from fatigue takes longer than 20 minutes. According to L. A. Wallrich and M. Dawson, a worker doing strenuous work is benefited by rest and thus can increase his efficiency, but a worker doing light work is inclined to be less efficient after a rest. The effect of rest on a worker who performs an ordinary job, a job neither strenuous nor too light, is insignificant. In short, whether there should be a rest period, how long it should be, and similar problems should be determined by actual circumstances. Generally, rest periods should be in the intervals between performances. In other words, the workers should get a rest period before they are completely fatigued. It is not advisable to wait until the workers get very tired and then give them a longer rest period. However, the number of rest periods should not be high, for they would then become difficult to administer.

Technical progress is necessary for shortening the workday and increasing work efficiency. There is little opportunity to shorten or lengthen the working day in a handicraft industry, where an increase in work speed brings a considerable amount of fatigue. However, the use of machines saves the energy of the worker and requires less mental exercise. A man can work faster and better with machines than with his hands.

Plant organization is also important in determining efficiency. A plant with poor organization sometimes wastes 50 percent of its working hours. It also wastes time because of poor management of materials and inadequate handling of designs. Inefficient organization, laxity in discipline, and talking during working hours are rather common phenomena. Thus, the ability and diligence of the industrialists also become a factor in determining the duration of working hours. Labor efficiency is also affected by the sanitary conditions of the plant, including ventilation, temperature, humidity, and vibration of machines. To avoid the loss of working hours, a plant should improve its sanitary conditions.

The shortening of working hours and the increasing of work efficiency also depend on the worker himself, particularly on his enthusiasm for his work. The ability to work should not be confused with the willingness to work. Many workers capable of work lack the willingness to work. Workers are often influenced by mob psychology. Sometimes the efficiency of a plant is affected by unconscious imitation among the workers. If a few workers slow down, others may follow, thereby diminishing the efficiency of the entire body of workers. High or low wages directly or indirectly affect the physiology and psychology of the workers and therefore their efficiency. If a worker receives very low pay and works very short hours, he cannot improve his efficiency, since his health deteriorates as a result of poor nutrition. On the other hand, high wages do not necessarily improve the efficiency of a worker who is habitually extravagant. A shorter workday may not increase efficiency if the workers receive low pay and have to spend much time in their own household work. All in all, if a shorter workday is to result in high efficiency, it must be accompanied by higher wages and by high worker morale. Shortening the workday is the first step in improving the lot of the workers, and measures should therefore be taken to that effect.

III. INDUSTRIAL FATIGUE AND REST

A. Causes of Industrial Fatigue

Fatigue results from repeated physical and mental exertion. A fair amount of work may cause fatigue which can be overcome after a rest. A man who overworks himself will feel exhausted and become ill. Thus, the study of the causes and effects of industrial fatigue and the remedies for it are important in industrial health studies.

The direct consequence of fatigue is lowered output and waste of materials. Fatigued workers work slowly and with less accuracy. The ultimate effect of fatigue is an increase in the number of accidents and in sickness. When fatigue is reduced to a minimum and efficiency is increased to a maximum, the living standard of the worker will be improved by shortening the workday or raising wages.

Fatigue is caused by the sudden contraction of muscles, disturbing the body's physicochemical equilibrium. Work produces, in the muscles and blood, phosphoric acid and lactic acid which, in turn, produce carbon dioxide and other fatigue-causing substances. A man doing light work can assimilate enough oxygen and thus counteract the reaction of the phosphoric and lactic acids. Consequently, a man working at a moderate rate can continue without fatigue for a rather long time. However, when he works at an accelerated rate, he cannot assimilate enough oxygen. Fatigue is in fact caused by a deficiency of oxygen and thus can be remedied temporarily by increasing the speed of breathing.

At the beginning of work, efficiency is growing and output is increasing because the muscles are more relaxed and the nervous system is more adaptable to the job. As the fatigue-causing substances gradually build up in the body and as the supply of oxygen is gradually depleted, the efficiency of the worker decreases. If he continues to work without rest, his muscles become inflexible and cease to function properly. However, this seldom occurs in factory work.

If work is done at a moderate speed, no cumulative fatigue results, since the muscles have a chance to recover after each contracting movement. A regular system of pauses, e.g., 5 minutes of rest for each hour of work, is sufficient for recovery from fatigue. Complete recovery can be effected by a long rest at noontime and another at night.

It takes longer to recover from great fatigue accumulated from long working hours. Thus, if half an hour's work requires 5 minutes rest, then a full hour's work requires 10 or more minutes of rest. It is said that the relation between the increased working hours and the increased amount of time for rest is two to one. For instance, if working time is doubled, then the time needed for rest is four times as great. Fatigue from very strenuous work cannot be overcome by less than one night's sleep. Rest periods should be brief but more frequent.

B. Rhythm in Motions

Study of the function of rhythmical movement in work is important to the science of management. Rhythmical movement can increase efficiency and alleviate fatigue. Experienced workers can often work a full day without fatigue and with an output several times higher than that of apprentices because they develop rhythm in work. Therefore, workers in modern industries are taught to make rhythmical motions.

C. Methods of Estimating Fatigue

The three methods by which industrial fatigue can be directly or indirectly estimated are as follows:

1. Output Method -- This method can reflect fatigue most accurately. A chart may be drawn on the basis of the output for every hour or half hour. The chart shows when the maximum or minimum output occurs. It indicates also how fatigue is overcome after the lunch period and after rest periods, and how efficiency drops near the end of a workday. Other things being equal, such as work speed, light, and temperature, the difference in output per hour serves as an index of industrial fatigue.

The output curve for an 8-hour day is practically the same as the fatigue curve. Thus, when the workers are warming up for work, output increases. But as the workday progresses, output per hour gradually drops. After the lunch period output increases again, but the decline in output occurs earlier in the afternoon than in the morning. The rate of decrease is also greater than that in the morning. However, output per hour may increase somewhat near the closing hour. This may be due to the last-minute rush.

2. Qualitative Method -- If the work is performed at the same speed as the movement of the machines, the amount of output per unit of time will be the same throughout the working hours. If this is true, it follows that the quality of the output throughout the working hours serves as an index of fatigue. This is true because fatigue adversely affects the accuracy, carefulness, and strength of the workers.

3. Lost Time Method -- The time lost from illness or accidents serves also as an index of fatigue, for fatigue is the basis cause of illness and accidents. Absence from work on account of illness or accidents may be studied in its relation to daily working hours, day or night shift, length of rest periods, and rate of performance. On the basis of a field investigation. Bogardus discovered that the accident rate is greater in the late morning and the late afternoon, and accidents occur more frequently in the afternoon than in the morning. Since accidents due to negligence can occur at any time during working hours, those which occur more frequently at particular hours can be attributed to fatigue.

D. Working Hours and Efficiency

As concerns the weekly output curve, production efficiency varies by days as well as hours. Output is low on the first day of the week, reaches the highest point on the second and third days, and then gradually declines, picking up a little on Saturday. The movement of such an output curve reflects the accumulative increase of fatigue. The workers apparently cannot recover completely from fatigue overnight. Thus, they very often feel more tired today than yesterday.

Mental fatigue or boredom is of course one of the major causes for reduced production efficiency. On week ends, a change of environment or outdoor living is as fruitful as bodily rest. The low output on Monday may be explained by the fact that the workers are tired from their week-end activities or by the fact that it takes time for them to regain their skills after the interruption of work over the week end. Besides, new assignments often come on Monday.

In regard to working hours, experiments on the relationship between working hours and production efficiency should be conducted over considerable time to eliminate extraneous factors that may affect the accuracy of the experiment. The experiment usually covers several weeks.

During the past century, working hours have been reduced from 12 to 8. The experience of the ammunition plants of Great Britain proves that long hours are conducive to low efficiency. According to a study made by Miles and Angles, if the weekly working hours are shortened, production per hour increases. However, the number of working hours should not be too low. A short work week does not contribute to the increase of work efficiency. The reason is that if the work week is too short, the number of working hours required for the preparation of work and other preliminary activities will become greater in relation to the total working hours. A 40- or 42-hour week is believed to yield the highest efficiency.

The losses resulting from a shorter working week are compensated for by increased production. Also, savings of electricity, fuel, and water can be realized from a cut in working hours.

E. Overtime and Nightwork

Overtime work increases fatigue and therefore lowers the efficiency for the work of the following day. In other words, the amount of work added by overtime work is sometimes smaller than the amount of work lost because of the overtime work. Prolonged working hours on a strenuous job are very exhausting. Overtime work not only lowers efficiency, but also causes loss of sleep and thereby exposure to ill health. If overtime work is necessary, the schedule should be prepared only after carefully examining the assignments. Generally, a factory should avoid overtime work or should use it only in an emergency. A worker should not be required to do overtime work consecutively for several days.

It is better for a plant not have nightwork. Objections to nightwork are for either physical or sociological reasons. A man cannot become accustomed to night life, since he is not made that way. Man is inherently a day-life animal. He cannot work all night and sleep in the daytime. Nightwork deprives the worker of the enjoyment of sunlight and may lead to anemia.

Several points should be kept in mind for nightwork operations: (1) a factory operating on a 24-hour basis may divide the working force into one day shift and two night shifts; (2) the night shift should not be longer than the day shift; (3) the night shift should include some daytime and should not interfere with a normal daily life; and (4) a rotation system should be adopted under which a worker would not be assigned to nightwork more than one week each month.

F. Rest Periods

Inasmuch as fatigue accumulates at an accelerated speed, workers should be given several rest periods, and each rest period should be short. One rest period during the morning is sufficient to delay fatigue. A worker should be given a rest when, or before he is fatigued.

Rest is necessary for any work requiring physical exertion. A factory should set up a rest schedule for the workers. Without such a permitted rest period, workers will have to resort to various disguises to get a rest. In general, a man doing very heavy work should take a 45-second rest for every 10 minutes of work, and a transport workers should take 25 minutes for rest after each hour of work. Rest is of special importance in mental work, although rest periods cannot be given on an hourly basis.

Some plants provide no rest period for the workers in view of the fact that they get a rest while waiting for materials, or during unavoidable interruptions. This is not right, for the workers cannot get a real rest since they do not know how much time they have. In fact, waiting is even more tiring than working for the same period.

Methods of relaxation should be carefully chosen. Alternating various methods of relaxing produces good results. Walking outdoors and playing games, are not very effective in overcoming fatigue.

G. Static Fatigue

Static fatigue, a special kind of fatigue, is caused by lack of exercise. Maintaining any one posture for a prolonged period will cause static fatigue. Moderate exercise will alleviate this type of fatigue.

IV. DETERMINATION OF OPTIMUM AMOUNT OF LABOR FOR A GIVEN JOB

A. Definition

An optimum amount of labor means the number of workers a specific job requires. A job must be performed by an adequate number of workers, properly organized as a team. There are three types of optimum quantity of labor: (1) an optimum quantity of labor as determined by the work of the machines; (2) an optimum quantity of labor as determined by the skill of the workers and the efficiency resulting from the organization of the workers; (3) an optimum number of managerial personnel.

The number of workers should correspond to the work of the machines. In other words, too many workers for a given number of machines results in a waste of human resources, while too few workers lowers efficiency. The purpose of determining the optimum quantity of labor on the basis of labor skill and organization is to develop fully the potential strength of the workers so that production may reach the highest level. The objective of determining the optimum number of managerial personnel is to reduce the cost of operation without endangering administrative efficiency.

B. Analysis of the Situation

Adequate preparatory work must precede changes in the number of personnel. It is wrong to decrease or increase the number of employees without definite plans, or to copy the hiring policy of other plants. Before any firing or hiring is done, the plant operations and the personnel administration system of the plant must be studied carefully.

If the number of personnel is to be determined on the basis of existing equipment and facilities, operations must be observed. For instance, the operations of a cement plant are done in three stages: raw materials, semifinished products, and finished products. Each stage uses specialized equipment: the rock-grinding machine for the first stage, the kiln for the second stage, and the cement-finishing machine for the third stage. There are also many auxiliary machines. One should first determine the optimum number of workers required for each specialized machine and then study how these machines are coordinated in operation. Finally, one may determine the number of workers the complete production process requires.

The second type of optimum quantity of labor is determined by a careful study of the following problems: Is the present labor force efficiently organized? Are there too many employees? Is the full labor potential being utilized? Have the workers reached optimum efficiency? Generally, maximum production has not been reached by a plant which has not yet launched a production contest or adopted a wage system based on piecework. A plant may have too many workers in one department and too few in another.

Furthermore, the productivity of each worker will increase if the workers are challenged to engage in production competition between plants and workshops. A piecework wage schedule and a bonus system for rewarding the surpassing of quotas also contribute to increased efficiency.

Determining the number of administrative personnel is rather complicated. Some administrative personnel are incompetent. Job assignment in the administrative department is not precise. Furthermore, since there is no definite measurement of managerial efficiency, it takes time to observe the results of any experiment. Bureaucratic attitudes and inefficient handling of office matter cannot always be easily discovered. In short, it is difficult to reform the administrative department. The responsibilities of each member of the managerial personnel must be studied and then his ability carefully evaluated. It should be determined how many persons are needed for various types of work and what kinds of persons are qualified. For instance, in the cost-accounting department, one should determine experimentally how many accountants and bookkeepers are needed before an appraisal of the personnel system of the entire plant is made.

C. Determining the Number of Personnel

After careful study, the number of personnel may be determined according to the following considerations:

1. Labor efficiency -- Unless the optimum number of workers for a job is determined on the basis of the average output of a progressive worker (or norms), the efficiency of the workers will be lowered. The optimum amount of labor for a job cannot be determined subjectively. The following example illustrates how the number of workers is determined.

Assume that the working hours required for one worker to produce one ton of rock are as follows (in hours):

Average norm 2, January 2 1/3, Febrary 2 1/4, March and April 2 1/6, May 2 1/12, June 2, July 1 5/6, August 1 3/4, September and October 1 2/3, November 1 5/6, and December 2.

If the annual quota is 100,000 tons of rock, the total number of working hours for the job would be 100,000 multiplied by 2, or 200,000.

If there are 306 workdays during the year and each worker works 8 hours a day, then each worker contributes 306 times 8, or 2,448 hours a year.

Thus the number of workers is equal to 200,000 divided by 2,448, or 82.

2. Average attendance rate -- If the average attendance rate in the above example is 80 percent, an additional 20 percent of workers will be needed.

A low attendance rate could be caused by poor health facilities; low wages, which give rise to a high turnover of workers; poor saftey conditions, which account for frequent accidents; or lack of education. In other words, some workers consider leave or absence normal. If the attendance rate can be raised to 95 percent from 80 percent, the 150 workers out of every 1,000 can be used for other purposes. If this increase is effected in every factory in the nation, millions of workers can be spared for use in national economic reconstruction. A high rate of absenteeism among skilled workers is an obstacle to national economic reconstruction. The attendance rate must be increased by introducing production campaigns, bonus systems, propaganda, and educational facilities.

3. Labor legislation -- Each country has its own labor laws which set the limit for workdays and working hours. Each plant also has a system of annual leave. In fact, a plant with continuous operation usually hires additional workers to do the work of those on sick leave or vacation. In a 1,000-worker plant allowing 60 days of leave for each worker, the total number of workdays lost in leave will be 60,000 a year. This is equal to 60,000 divided by 300 (assumed to be the number of legal workdays), or 200 workers. The plant must therefore hire an additional 200 workers to keep the plant in continuous operation.

V. DETERMINATION OF TIME STANDARDS

The determination of a standard time for each job is essential to the efficient use of manpower and the elimination of waste. Constant inspection of the time standard can result in better work methods and in setting up a better wage system. By accurate study, analysis, and planning of time standards, labor and machinery can be utilized efficiently and the time of the operation can be minimized. With accurate knowledge the the time necessary to perform a task and to establish thereby a standard time the methods of performance can be improved, and quality and quantity raised.

A. Classification of Worktime

Worktime can be classified according to the nature of the work. The purpose of classifying worktime into elements is to find out the causes of useless motion and to establish a yardstick for operations.

The following is a classification of worktime:

1. Production time (P) refers to the time necessary to perform the task at hand. It may be broken down into the following time elements:

a. Preparation and termination time (S) which represents the time necessary to prepare and to conclude the task at hand. It includes time taken in connection with the day's work in general (S_1) and with a particular task (S_2).

b. Basic time (F) is the time consumed in the operation, or the time used by the worker in changing the physical or chemical properties of the materials he works on with the help of machines and tools. It includes:

(1) Handling time (F_1), which refers to the time given to manual work without the assistance of electric, steam, water, wind, or other mechanical power.

(2) Machine time (F_2), which denotes the time for the work done by machines without the participation of workers.

(3) Machine and handling time (F_3), the time taken by both the machines and the workers.

c. Auxiliary time (A) is the time taken by motions of secondary importance but necessary for the main task.

2. Nonproduction time (N) refers to the time spent in usless motion by the worker. It includes:

a. Time lost through other than the fault of the worker (N_1), specifically time lost through poor organization.

b. Time lost through the fault of the worker (N_2), i.e., time lost as a result of incompetence, lack of skill, or failure on the part of the worker.

3. Delay (D) refers to the time lost through interruptions of work for personal reasons of the worker or extraneous circumstances. This includes:

a. Technical delay (D_1), which is the delay caused by technical reasons.

b. Organizational delay (D_2), denoting the time lost by interruptions resulting from poor work organization.

c. Personal delay (D_3) meaning interruptions of work for personal reasons.

B. Computation of Worktime Consumption

The methods for the computation of worktime are as follows:

1. Preparatory and termination time

a. In the preparation and termination time for a workday, $a = \frac{S_1}{W \times 100}$, where a equals the preparation and termination time as a a percent of the total worktime (W).

b. In the preparation and termination time for a certain job, $S_2 = \frac{C}{n}$, where C equals the preparation and termination time for a work order, and n equals the number of jobs in the work order.

2. In regard to permissible delay, $b = \frac{D}{W \times 100}$, b being the permitted delay in percent of actual worktime.

3. Computation of working hours per unit of product and of output.

a. Unit worktime (U) refers to the standard time taken to produce one unit of the product, expressed usually in terms of man-hours or man-minutes. It is the total of the following three times:

(1) Actual worktime (W), which equals F+A.

(2) Preparation and termination time (S), which equals $S_1 + S_2 = W \times \frac{a}{100} + \frac{c}{n}$.

(3) Permissible delay (D), which equals $W \times \frac{b}{100}$.

Thus, $U = W + S + D = W \left(\frac{1+a+b}{100}\right) + \frac{c}{n}$.

b. Output (H) is equal to $\frac{K}{U}$, or the total working time divided by the time taken per unit of the product.

C. Preparation and Analysis of the Observation Sheet

One of the important steps in time study is to record on an observation sheet the time spent on each work element or motion and then to proceed with the analysis. It will then be possible to find out what time is necessary for the operation and what time is lost in useless motion. The observation sheet is therefore a valuable record from which a standard preparation and termination time or a standard permissible delay can be determined.

Time and motion study includes the following three phases:

1. Preparation phase -- The observer should have a stop watch, an observation sheet, and a wooden board. He should make a preliminary study of the subject matter he is going to observe, including an analysis of the operation, the selection of an observation position, and the determination of the worker to be studied. Before making the time study, he should explain to the workers the significance of his study in order to secure cooperation from them.

2. Investigation phase -- The observer should enter the time of the start of work on the observation sheet. When the worker shifts from one motion to another, the observer should enter this time as indicated by the stop watch in the column of the observation headed "circulating time." He should give a brief description of each motion in the column headed "motions under observation."

The following points should be kept in mind:

a. Give a detailed description of each motion in the column headed "motions under observation," with specific emphasis on the causes of wasted time to pave the way for further analysis.

b. Fill out the column headed "causes of absence" only after talking with the worker on his return, instead of filling out the sheet from speculation.

c. Note carefully whether the worker is fully occupied when the machine has started working and whether the machine requires his full attention.

d. Do not leave the post lest the observation be interrupted. Do not talk to the worker being studied or interfere with his work.

e. Enter the data directly on the observation sheet to avoid errors in the transfer of data.

f. Determine the methods of investigation from the nature of job.

g. The number of observations required to secure sufficient information on any operation will vary with the number of times a motion is repeated. If the motion does not involve much repetition, two observations covering the entire motion are necessary.

After a number of observations, the observer should arrange his data and compile a working-hour computation form from which the average amount of time spent for each motion can be computed. The average amount of time can then be used for rate setting or further analysis of operations.

3. Analysis phase -- The last stage in time study is to ascertain the standard time for each motion. Measures should be taken to utilize all the available man-hours for the work to be done. This will require various statistics, including the time-element sheet, the delay-analysis sheet, and the synthetic time-analysis sheet.

There are two groups of time-study records:

1. Workday records of individual workers -- These consist of the following forms or tables:

a. A table showing working hours consumed by the individual worker -- This table records the work done by each worker during the workday. Work descriptions should be detailed and precise, since all data recorded in this table are source data (see Table 1 below).

b. Time-element sheet (see Table 2 below) -- This is a table showing the times consumed by the same motion and is constructed on the basis of Table 1.

c. Time computation sheet (see Table 3 below) -- This is compiled by averaging the time values in Tables 1 and 2. A delays-analysis sheet (see Table 4 below) can then be compiled on the basis of Table 3 after an analysis of the various times consumed in the operation. The standard used in Table 4 is that stipulated in labor legislation; for instance, the preparation and termination time may not be greater than 2 percent of the working hours, and the rest period and time spent in personal conversation may not exceed 2.5 percent of the working hours.

d. Synthetic time-analysis sheet -- On the basis of Table 4, a synthetic time-analysis sheet can be compiled for use as a guide in eliminating waste time and useless motion. Delays listed in the delay-analysis sheet should be noted and counted as part of working hours and should be placed under basic time (F) and auxiliary time (A) (see Table 5 below).

e. After making the time study and improving the arrangement of work, the ratio of production increase can be computed in the following manner:

$K = \frac{W_1 + W_2}{W \times 100}$, where W_1 is the number of actual working hours after the increase in efficiency, W is the number of actual working hours before the increase in efficiency, and K is the increase in production.

f. A time-study card for the individual worker can be compiled from the work record in order to compute the standard working hour for the worker.

2. Working-hour records for a group of workers -- These records describe the performance of a group of workers rather than of the individual worker. Each group consists of 12 workers or less. The procedure in compiling these records is similar to that used for individual workers. These records include the following tables or forms:

a. Working record of worker team (Table 7)

b. Time-study observation sheet for worker team (Table 8)

c. Delay-analysis sheet for worker team (Table 9)

d. Synthetic time-study sheet for worker team (Table 10)

Table 1. Motion Observation Sheet for Individual Worker

____ Bureau　　____ Form No　　____ Plant　　____ Team

Observation:				Worker				
Order	Date	Motion Beginning	Ending	Name of Worker	Wages	Skill	Working Age	Distinct Ability

Observation Record No ____

Order	Motion Under Observation	Circulating Time	Length of Time	Abbreviation
(1)	(2)	(3)	(4)	(5)

Notes:
(1) Order of the motions under observation, using numerals 1, 2, 3, etc.

(2) Describe the motions briefly, e.g., picking up tools, walking to the job, rest, etc.

(3) Fill in with hours and minutes, e.g., 0809, 0835, 0910, etc.

(4) Equal to the difference between the two times in sequence in the circulating time column, e.g., 0835 - 0809 equals 26 minutes, 0910 - 0835 equals 35 minutes, etc.

(5) Use symbols for different categories of times, e.g., S_{1-1}, S_{1-2}, F_{1-1}, F_{1-2}, etc.

Table 3. Computation Sheet for Time-Study Observations

Categories of Time	Symbols	Motion Elements	Observation 1	Observation 2	Observation 3	Total	Average
Production time, preparation and termination time concerned directly with work on hand	S_1-1	Prepare to go to workshop					
	S_1-2	Put workshop in good order					
	S_1-3	Pick up personal tools					
	S_1-4	Workday begins and terminates (before and after lunch, arrival for and departure from work)					
	S_1-5	Receive or deliver supplementary materials					
	S_1-6	Receive work instruction					
	S_1-7	Change tools					
	S_1-8	Repair tools occasionally					
	S_1	Total					
Production time, preparation and termination concerned directly with a certain job.	S_2-1	Receive or transfer a job					
	S_2-2	Transfer to another job					
	S_2-3	Study job assignment					

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Table 2. Time-Element Sheet

Time Consumed					
Symbol	Elements	Number of Repeated Motions	Total Length of Time	Time Element in Minutes	Average Length of Time for Each Motion
(1)	(2)	(3)	(4)	(5)	(6)

Remarks:

Compiled by ______ Date ______ Edited by ______ Date ______

Notes: (1) Add the identical symbols in column (5) of Table 1 together.

(2) Abbreviations identical to those in column (2) of Table 1.

(3) Number of identical symbols in column (5) of Table 1.

(4) Total time of the identical symbols listed in column (5) of Table 1.

(5) [Sic; should be (6) Equal to (4) divided by (3).

[(6) See (5); explanation of (6) not given]

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Table 3. Computation Sheet for Time-Study Observations

Categories of Time	Symbols	Motion Elements	Observation 1	Observation 2	Observation 3	Total	Average
Production time, preparation and termination time concerned directly with work on hand	S_1-1	Prepare to go to workshop					
	S_1-2	Put workshop in good order					
	S_1-3	Pick up personal tools					
	S_1-4	Workday begins and terminates (before and after lunch, arrival for and departure from work)					
	S_1-5	Receive or deliver supplementary materials					
	S_1-6	Receive work instruction					
	S_1-7	Change tools					
	S_1-8	Repair tools occasionally					
	S_1	Total					
Production time, preparation and termination concerned directly with a certain job.	S_2-1	Receive or transfer a job					
	S_2-2	Transfer to another job					
	S_2-3	Study job assignment					

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	S_2-4	Apply for study and design
	S_2-5	Apply for special tools
	S_2-6	Return special tools
	S_2	Total
Basic production time	F_1	Handling time
	F_2	Machine time
	F_3	Machine-hand operating time
	F	Total
Auxiliary time	A	Total
Production time	P	Combined total
Nonproduction time, beyond control of worker	N_1-1	Seek tools or materials
	N_1-2	Make a trip to affiliated plant for materials
	N_1-3	Repair defective products made by others

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	N_1-4	Repair tools or fixtures not for immediate use
	N_1-5	Useless motion due to failure to set up machines in time
	N_1-6	Pick up parts for unskilled workers
	N_1-7	Do jobs not falling into worker's specialization
	N_1	Total
Nonproduction time for which worker involved is responsible	N_2-1	Repair own defective products
	N_2-2	Spend more time on a job because of lack of experience
	N_2-3	Motions not concerned with assignment
	N_2-4	Delay due to use of unsuitable tools
	N_2	Total
Nonproduction time	N	Combined total

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Delays, for technical reasons	D_1-1	Do nothing when machine moves
	D_1-2	Wait for the completion of other motion elements
	D_1	Total
Delays, for organizational reasons	D_2-1	Wait for work, materials, or order
	D_2-2	Wait for supplemental labor or power supply
	D_2-3	Wait for repairs or installation
	D_2-4	Delays due to the lack of standardization in materials and products
	D_2	Total
Delays, for personal reasons	D_3-1	Authorized breaks during working hours
	D_3-2	Arrive late for work or leave early
	D_3-3	Take unauthorized breaks or converse with others
	D_3	Total
Delays	D	Combined total

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Working hours (production plus nonproduction plus delays)	T	Total

Notes: Column (4) on the number of observations is obtained from column (4) in Table 2.

Table 4. Delay-Analysis Sheet

Order	Symbol	Incidental to	Duration in Minutes	Causes of Delay	Suggested Remedies	Possible Results
1	S_1	Preparation and termination			Adhere to the 2 percent margin provided by labor laws	
2	N_2	Useless motion		Incorrect method	Give warning	
3	N_1	Looking for parts or engaging in work requiring no skills		Poor organization or work	Give warning	
4	D_2	Waiting for assistants or for power supply		Poor organization in planning	Strictly follow the blueprint and work schedule	
5	D_3	Resting or engaging in conversation			Adhere to the 2.5 percent margin	
			Total			

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Table 5. Synthetic Time-Analysis Sheet

Time Categories	Time Elements	Symbols	Actual Figures: Length of Time (minutes)	Actual Figures: Percent of Work Hours	Actual Figures: Percent of Operating Time	After Being Strengthened: Extended Time (minutes)	After Being Strengthened: Percent of Work Hours	After Being Strengthened: Percent of Operating Time
			(1)	(2)	(3)	(4)	(5)	(6)
Production time	Preparation and termination concerned with working day	S_1						
	Preparation and termination concerned with a certain job	S_2						
	Basic time	F_1						
		F_2						
		F_3						
	Auxiliary time	A						
	Production, total	P						

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Nonproduction time	Beyond worker's control	N_1
	Within worker's control	N_2
	Total	N
Delays	Technical nature	D_1
	Poor Organization	D_2
	Personal reasons	D_3
	Total	D

Notes: (1) Transferred from column (1) in Table 4

(2) (1) divided by T

(3) (1) divided by $F_1 + A$

(4) Column (1) in Table 4 minus column (4) in Table (4)

(5) (4) divided by T

(6) (4) divided by $F_1 + A$

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Table 6. Work Record for Individual Worker

_______Company _______Plant _______Team

			Personal Data					
Order	Observation Date	Name of Worker	Wage Rate	Position	Work Age	Specialization	From	To

Order	Observation No	Job Description	Working Hours	Output Per Day	Output Unit Per Day	Minutes Per Unit of Products (in average)			
						Working Time	Preparation and Termination	Delays	Total
						W	S_1 S_2	D	

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Table 7. Work Record for Team

________ Bureau	________ Company	_____ Plant	_____ Work Team

Job Description and Level	Worker: Name	Machine Used: Name
	Position	Serial
	Grade	Grade

Circulating Time	Workers:
	1
	2
	3
	4
	5
	6
	7
	8
	9
	10
	11

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Table 8. Working Hours for Work Team

Working Hours Consumed				Length of Time (in minutes)											
				Workers											
Categories	Motion Elements	Working Hours Consumed	Symbols	1	2	3	4	5	6	7	8	9	10	Total	Average

Table 9. Delays Analysis Sheet Work Team

Order	Symbols	Incidental to	Time Lost (in minutes)	Causes for Delays	Suggested Remedies	Possible Results	Remarks
1	N_1	Looking for Tools		Poor organization of work	Improve the whole process		
2	D_2	Waiting for order or materials		Poor planning	Strenthen operation planning		
3							
					Total		

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Table 10. Synthetic Time Analysis Sheet for Work Team

			Actual Average Times				Final Breakdown		
Categories	Elements	Symbols	Observation	Total	Average	As Percent of Working Day	Time Consumed	As Percent of Working Day	As Percent of Operation Time
			1 2 3 4 5 6						
Production time	Preparation and termination	S							
	Operation time	W							
	Total	P							
Nonproduction time	Beyond the control of workers	N_1							
	Due to personal reasons	N_2							
	Total	N							
Delays	Technical nature	D_1							
	Poor organization	D_2							

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Due to personal reasons	D_3
Total	D
Total working hours	T

D. Time and Motion Study

The purpose of a time study is to ascertain the duration of various motion elements involved in the complete working process. With the aid of a time study, one can discover the causes of useless motions, shorten the time required for various motions, and help reduce the operation time to a minimum. The time study differs from the recording of daily work in that it studies only the motion elements rather than all work performed in a day.

1. Job Analysis -- A job may be broken into four elements:

a. Job unit -- The work done on a task by a worker or a team of workers.

b. Basic performance -- A part of the job unit, the work performed on an object without the change of tools or facilities.

c. Handling -- A part of the basic performance involving several motions.

d. Motion -- The simple movement of the body.

2. Recording the time -- Names of the motions or elements in a time study should be written down on the observation sheet before timing. There are four methods of recording the time:

a. Over-all timing method -- All the motions or elements are treated as one complete process. The stop watch is kept running throughout the operation. Since this method cannot discover useless motion and idle time or lead to the improvement of the operation, it is used for checking purposes only.

b. Repetitive method -- Each element is taken separately several times. The purpose of such a method is to make a close study of a specific motion or element for improvement.

c. Continuous method -- In this method, the watch is kept running throughout the period of operation. The readings of the watch at the end of each element are recorded against the list of elements previously listed in proper sequence on the time-study observation sheet. This is considered the most satisfactory method of timing.

d. Cycle timing -- To ascertain the time for each element of relatively short duration in a continuous operation, the timing is made in groups. One such method is to record the time of all elements in the cycle less one. After a number of cycles are timed, the time for the omitted element can be obtained by subtraction.

3. Procedure in making time study.

a. Preliminary investigation -- This should include an examination of all the conditions surrounding the operation under study, such as the work requirements, condition of the materials, etc. Tools and forms used in the study should be ready for use. The following preparations should also be made:

(1) Improve the procedure in issuing raw materials and parts;

(2) Eliminate useless motions;

(3) Select suitable tools and facilities so as to save time and reduce fatigue;

(4) Remove objects which are not going to be used in the workplace;

(5) Prepare an adequate operational procedure for better coordination among the workers; if the procedure is found inadequate revision should be made before the resumption of the time study.

b. Observation -- When recording the times for the motion elements in the time study form (Table II), the observer should make sure that the operator follows the proper procedure correctly in every motion.

c. Analysis -- Calculate the value of the safe ratio listed in Table 11 and the average duration for each motion and compile the work-time analysis table (Table 12).

(1) A safe ratio for a motion is obtained by dividing the maximum time by the minimum time for performing the motion. It should not exceed 1.4 in the case of making parts and in mass-production finishing work.

(2) The average time for each motion is obtained by dividing the total time recorded in a number of observations by the number of observations.

E. Conclusion

A standard wage rate determined by the standard time for the job and by the quality of the products is essential for the raising of production capacity. Standard time is the amount of time necessary to perform a job or to produce a unit of the products in an industrial enterprise, assisted by modern production experience and guided by scientific management. Standard amount of output means the amount of products produced per unit of time.

The relationship between time and output is shown in the formula given in Table 13. The precise value of such a relationship can be obtained through time and motion study. Time and motion study helps to ascertain the standard time for various performances. It also helps to achieve an economy in time and effort.

Table 11. Operation Time Inspection Card

_____ Bureau   _____ Plant   _____ Workshop   _____ Team

Job Title _____   Job Level _____

Materials and Accessories			Tools and Parts			Worker				
Order	Name	Quantity	Order	Name	Quantity	Order	Name	Grade	Seniority	Characteristic

Times for Various Motions

Order	Name of Motion	Number of Workers	Circulating Time	Inspections	Total	Average	Safety Quotient
			Motion Time:	1 2 3 4 5 6 7			(Ratio of maximum operation time to minimum time)

Table 12. Operation Time Analysis

Delays					Analysis			
Number	Beginning	Ending	Duration	Causes	Number	Inspection	Number	Analysis of the Causes for Longest or Shortest Operation Time

Analysis of Time Study Record

Number of Motion	Factors for the Longest or Shortest Operation Time	Operation Time to be Shortened	Safety Quotient

Table 13. Mathematical Relations Between Time and Output

1.	$H = \frac{1}{T}$	Output equals 1 divided by length of time
2.	$H_1 = H \frac{(1 + a)}{100}$	Present output equals past output (1 plus percentage incerase of output divided by 100)
3.	$H_1 = H \frac{(1 - a1)}{100}$	Present output equals past output (1 minus percentage decrease of output divided by 100)
4.	$T_1 = T \frac{(1 - b)}{100}$	Present time consumed equals past time consumed (1 minus percentage decrease of time divided by 100)
5.	$T_1 = T \frac{(1 + b_1)}{100}$	Present time consumed equals past time consumed (1 plus percentage increase of time divided by 100)
6.	$a = \frac{(H_1 - H)\ 100}{H}$	Percent increase of output equals present output minus past output times 100 divided by past output
7.	$a_1 = \frac{(H - H_1)\ 100}{H}$	Present decrease of output equals past output minus present output times 100 divided by past output
8.	$B = \frac{(T - T_1)\ 100}{T}$	Percent of decrease of time equals past time length minus present time length times 100 divided by past time length
9.	$B_1 = \frac{(T_1 - T)\ 100}{T}$	Percent of increase of time equals present time length minus past time length times 100 divided by past time length
10.	$a = \frac{100\ B_1}{100 - B}$	Percent increase of output equals 100 times percentage decrease of time divided by 100 minus percentage decrease of time
11.	$a_1 = \frac{100\ B_1}{100 + B_1}$	Percent decrease of output equals 100 times percentage increase of time length divided by 100 plus percentage increase of time length
12.	$B = \frac{100\ a}{100 + a}$	Percent decrease of time length equals 100 times percent increase of output divided by 100 plus percentage increase of output
13.	$B_1 = \frac{100\ a_1}{100 - a_1}$	Percent increase of time equals 100 times percentage decrease of output divided by 100 minus percent decrease of output

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Part 2. THE PROTECTION OF INDUSTRIAL WORKERS

I. SAFETY OF INDUSTRIAL WORKERS

A. Buildings

Industrial buildings must be safe in order to protect the health of the workers, prevent accidents, and improve efficiency. The following factors should be taken into consideration with respect to industrial buildings:

1. Load -- The load of a building is designed to suit the purposes of the building. Buildings for different purposes may have entirely different carrying capacities. Thus a dwelling house or an office building may not be suited for industrial use because of the difference in loads. According to the construction standards of Shanghai, each floor of an industrial building must have a carrying capacity of 500-750 kilograms per square meter. A capacity 25-50 percent higher than the burden of the machines and fixtures is needed for a machine shop. If a building must carry a load higher than the above-mentioned standard load, it should be built according to the capacity so desired.

To guarantee industrial safety, each industrial plant should ask an architect to inspect its building thoroughly. It should lower the burden of its building space if the building is getting too old. If the actual load of a building is more than its installed capacity, the building must be reinforced or a new arrangement of the workplace must be made, as by shifting those machines with greater vibration to the ground floor or removing some of the machines.

2. Fire protection -- According to the building regulations of Shanghai, an industrial building with four or more stories must be built with fireproof materials. A building with three stories or less must have its stairs and floors built with fireproof materials. A building designed for the manufacture of inflammable goods should have fireproof ceilings, floors and stairways, and if it occupies more than 280 square meters, each floor should have two fire exits.

An industrial plant with more than three stories or one which employs 100 workers or more should install a fire hydrant, fire extinguisher, or sandbox. If it is over 15 meters high, it should install fire hydrants outside the walls. If it is over 23 meters high, pumps and water tanks should be installed. The number, quality, location, and specifications of these fire-protection devices should be inspected and approved by the city government.

Safety doors should (1) be made of fireproof materials or wrapped in lead foils, (2) be double doors with each half not less than .5 meter wide or 2 meters high, (3) be not farther than 25 meters from the workplace, (4) open outwards, (5) lead directly to a safe area, (6) be clearly marked, and (7) remain unlocked during working hours.

Fire escapes should (1) be made of fireproof material; (2) have a slope of less than 45 degrees; (3) have firm rails; (4) not be narrower than 0.6 meter; (5) have each single step not higher than 20 centimeters, with a depth of not less than 21 centimeters; and (6) not be curved.

There should be no obstructing objects in the passage connecting the safety doors and the fire escapes. Doors and windows within a radius of 2 meters of the fire escapes should be free from fire hazards. Dangerous materials or finished products should be kept away from the other materials or products or should be equipped with fire-prevention devices.

B. Machine and Power Safety

Safety in handling machines has become a major problem in industrial safety, since in modern manufacturing and mining industries machines are the principal means of production.

Generally speaking, machine troubles are not caused so much by the age of the machines as by the following factors: (1) unsatisfactory installation and unstandardized parts, (2) lack of a regular inspection and overhauling plan, (3) poor distribution of responsibilities, and (4) the lack of standard practice for handling the machines. These factors can determine the quality and quantity of the products and can affect the safety of the workers.

Here we shall limit our discussion to the safety of the workers. Before we use a new machine, we should learn about its construction and nature by careful observation, study, or inquiry. Those who operate a machine without either familiarity with it or previous experience will easily get into trouble. One should not operate a machine that is assigned to another person. One must know how to stop a machine before you start it. Otherwise, you may get a higher speed when you want a lower one, get panicky, and have an accident. A worker should be assigned on a permanent basis to refuel the main machines. Refueling should be done regularly and after the machines stop. One should check whether the refueling is still under way before starting the machine.

Stop the machine before changing the cutting tools or the speeds. When the machines stop at the end of the day or when there is a power failure, put all the working parts in a resting position so as to avoid their being started or moved accidentally.

Examine by hand to see whether there is any trouble with the machines before starting them. For instance, move the belts of a lathe by hand and see if they are loose or come into contact with the cutting tools. Use slow speed when starting a machine which has not been in use.

The parts of a machine which can easily cause accidents must be equipped with safety devices. For instance, belts hanging in the air should be either supported by metal frames or shielded, and the moving wheels which come into close contact with the workers should be covered by guards. The operator should stand to one side of the working table when testing a new grinding wheel in order to prevent accidents. Since workers in foundry and metalworking shops come into close contact with heated metals, they should have leather aprons, work gloves, boots, and safety goggles. Safety goggles are also needed when working on a grinding wheel to keep metal dust from getting into the eyes.

Heavy machines should not be moved by hand. If they must be moved by hand, the new location should be cleaned and prepared for the new machines. For instance, pieces of wood serving as a cushion should be arranged properly in the new location for the machine before its arrival.

C. Safety in the Power Supply System

Safety in the power supply system is as important as safety in the operation of machines, since modern industry uses electricity as practically its only source of motive power. A continuous supply of electricity which does not invite accidents is essential for all industries and mines. Failure in the power supply system may damage the health of the workers and sometimes menace their lives.

Each worker in the power supply industry should understand clearly the consequences of even a one-minute interruption in the supply of electricity in steel mills, glass furnaces, and chemical plants. They must also realize the damage that will be inflicted on mine workers and mining facilities once the pumps and air compressors in the mines stop because of power failure.

Several requirements of a safe power supply system are given below:

a. System -- An adequate body of work rules should be established. Performance responsibility should be established among the workers. Workers should be appointed on a permanent basis to take care of the operation of the generators and other essential machines under the supervision of the engineers or technicians. The operators of the machines should understand clearly the detailed instructions concerning the capacity and the starting and stopping mechanisms of the machines.

b. Boilers -- The injector and the water gauge of a boiler are very delicate devices. A defective injector may put the boiler out of operation or cause an explosion. The water gauge is also a very important mechanism in the boiler. If the level in the water gauge is too high, the excess steam may damage the turbine; if it is too low, the boiler may explode when the temperature becomes too high. Boiler accidents will not only interrupt the operation but also cause casualties. Thus, the water gauge must be put in a position convenient for inspection, and a worker should be assigned to examine it regularly.

c. Generators -- The following questions should be kept in mind: (1) Is the speed regulator defective? Is it inspected regularly? (2) Is the oil injector in good condition? Has the quality of the fuel oil been tested? (3) Has the temperature of the generator been regularly taken? (4) Is the machine checked regularly? Has it been overhauled? (5) Is there any weakness in the construction of the machine? How can this weakness be overcome? (6) Are there detailed operating instructions and plans?

d. Other considerations -- The grounding and lightning insulators in transformer stations should be inspected regularly. The use of cheap brass wire for fuses should be strictly forbidden. There must always be lubricating oil in the transformers. New parts must be tested before they are installed.

D. Ventilation and Industrial Safety

1. Mechanical air-circulating devices -- Adequate air-circulating facilities are necessary to prevent the accumulation of inflammable liquids or gases in a plant where such gases or other inflammable materials are present.

There are two types of air-circulating systems, natural and artificial. The former relies on natural forces such as wind or gravity to circulate the air, while the latter utilizes exhaust fans or blowers. Since the natural air-circulating system does not require special apparatus and is easy to operate, we should use it as much as possible. It can be used in a plant where only a small amount of inflammable gases accumulate.

A mechanical air-circulating system consists mainly of a set of fans and ducts. It is used in factories where inflammable gases or poisonous fumes are given off during the operations. It includes two systems: the blower system, which draws the fresh air into the plant, and the exhaust system, which drives the used air out of the plant. In a wider sense, a mechanical air-circulating system includes the air-conditioning system.

2. Air conditioning -- Standard air-conditioning equipment includes: (1) the fans which stimulate the air circulation; (2) the ducts which distribute the air to the space to the air-conditioned; (3) ducts for the returned air; (4) the air intake; (5) a spray mechanism to clean the air, regulate the humidity, and cool the air in the summer; (6) heaters to supply heat in the winter; and (7) refrigeration equipment, thermostats, etc.

From the viewpoint of fire and explosion prevention, an air-conditioning engineer should bear the following points in mind:

a. If a large space comprising several buildings is to be air-conditioned, the separate distribution system is better than the central station system, although the latter is widely used. This is because the separate distribution system does not require the nozzles and pipes to penetrate the walls and thus lessens the danger of widespread fire damage in case there is a fire. The wider the area covered by the air-conditioning system, the greater the possibility of a widespread fire or an explosion.

b. The heater in the air-conditioning unit should be carefully installed. Heated surfaces should not be in contact with woodwork or inflammable materials.

c. Highly inflammable, explosive, or poisonous refrigerants such as ammonia, methylnapthalene, dichlorethylene, ethane, and sulfur dioxide should be carefully handled.

d. Do not use an air filter made of inflammable material.

e. Oil used in the air filter should not have a flash point lower than 300 degrees [centigrade?]

E. Elimination of Inflammable Gases

Air-ventilation apparatus should be installed in areas where inflammable gases or liquids accumulate. These gases should be eliminated at the source. A metal cover may be used to prevent the escape of poisonous gases at the source. Since inflammable gases are heavier than air, the intake of the gravity ventilators should be placed close to the floor to gather the inflammable gases that accumulate there. Furthermore, it is helpful to drill some holes in the floor near the walls. These holes facilitate the exit of inflammable gases and the entrance of fresh air.

When moving gases encounter fire, or even sparks, an explosion will occur which may extend immediately to the source of the gases. An explosion may occur even if the sparks are 100 meters away from the source of the gases.

A plant not equipped with sufficient air-circulating devices may drill a number of holes in the walls and floors as outlets for inflammable gases. These holes in the walls must be near the floor if they are to be effective outlets for gases.

F. Humidity Control

Humidity control is also one of the major objectives of an air-conditioning system. Ordinarily, the purpose of humidity control is to produce comfort and to satisfy certain requirements in the production process. Humidity control is also very important for the prevention of fire hazards arising from the discharge of static electricity. The discharge of static electricity can cause an explosion in a workshop where there is inflammable gas in the air. A very small spark in such a place can cause an explosion. If the air contains sufficient humidity, the static electricity will disappear.

Generally, prevention of fire hazards from static electricity is ineffective when the relative humidity is 30 percent, can be slightly effective when the humidity is 40 percent, and very effective when the humidity is 50 percent. A humidity of 50-60 percent gives a very high (although not complete) degree of safety from explosions due to static electricity.

There are many ways to increase the humidity of the air, such as the use of an air-conditioning unit containing a humidity-control apparatus. If there is no air-conditioning unit, the relative humidity of the air may be increased by placing a number of water bowls or wet cloths in the room or by spraying water on the floor.

G. Handling of Inflammable Liquids

Some liquids used in industry burn at ordinary or below-zero temperatures, while others do not burn even when the temperature is as high as hundreds of degrees. The former group of liquids includes gasoline, and the latter group includes asphalt and quenching oil. Whether a liquid will cause a fire hazard is determined by its flash point. The flash point is the lowest temperature at which a vapor given off by a volatile oil will explode when mixed with air.

A liquid of very low flash point can frequently cause explosions. Paints, pigment, lacquer, and varnish are fire hazards even when spread thinly on a surface. Fire hazard is also great in the various stages of handling paints and in a plant which utilizes gasoline, fuel oil, or other inflammable materials. Solid substances such as tallow, wax, tar, and resin may be very hazardous when undergoing heat-treatment. Solutions of these substances are inflammable even at ordinary temperatures.

Fire sources in the workshop include for the most part short circuits in the motors, switches, or electric cords and the sparks produced by other electrical appliances. Sparks from static electricity and flames from illuminating lamps also create fire hazards. Other causes of fire hazards include overheated oil tanks, electric soldering irons, heated metals, machine friction, matches, and lighted cigarettes.

The following precautions should be taken in handling volatile liquids:

1. All inflammable liquids should be kept in fireproof storage. Workshops manufacturing or handling these liquids should have fireproof walls.

2. Fire from some inflammable liquids cannot be extinguished by water, although water may be used to absorb the heat generated by them. Therefore, a plant handling inflammable materials should be equipped with an automatic fire hose and various types of fire extinguishers such as foam, carbon dioxide, and carbon tetrachloride sprayers.

3. An explosion zone should be marked off in a plant where explosion hazards are present. The purpose of such a measure is to minimize possible damage to the buildings and other facilities.

4. Measures should be taken to prevent inflammable liquids or gases from being exposed to air, e.g., the use of enclosed containers.

Tightly sealed containers or pipes should be used for the transport of inflammable liquids. Direct pumps are better than those utilizing compressed air. If an open container is to be used as an oil tank, a sufficient air-circulating system must be installed

5. All electrical apparatus should be carefully selected and installed so that it will not produce sparks or become overheated. Grounding for each machine and the maintenance of adequate humidity can reduce sparks from static electricity. Electric soldering irons should be kept away from inflammable liquids.

II. INDUSTRIAL SAFETY FACILITIES IN THE SOVIET UNION

Safety facilities in the Soviet Union include the following measures.

A. Gradual Elimination of Hazardous Operations

The most effective method of eliminating industrial hazards is to make the production process automatic or simplified. Before the operations are entirely mechanized, preliminary steps can be taken to eliminate the hazards existing in certain stages of the process. For example, a rotating platform is installed on the upright drill. Since the platform can hold the object steady and feed it to the cutter, there is no need for the operator to feed the machine by hand. After each cutting operation, the platform advances and places the object under the cutter. The worker is no longer required to put his hands dangerously near the drill.

Safe operations require the use of automatic and mechanical devices as substitutes for manual work. These devices can minimize industrial hazards.

B. Integration of Safety Facilities

Safety devices should be installed on machines. They include wheel covers, shields, and protective plates. However, these safety devices will not work if the operator fails to follow the proper work procedure. It is necessary therefore to interlock the safety devices and the starting mechanism of the machine. In other words, the operator cannot start the machine unless the safety devices are properly set.

This feature should be copied by our manufacturing plants. At present, some plants do not use any safety devices, since they are not accustomed to them. They even take them off and put them alongside the machines, thus overcrowding the space and creating additional hazards. This situation can be avoided by interlocking the safety devices and the starting mechanism of the machines.

C. Safety Equipment for Individual Workers

Protective devices for individual workers such as goggles, special uniforms and boots, masks for welders, and safety belts for workers climbing high above the ground are very useful pieces of safety equipment.

The above-mentioned individual safety devices must be adapted to the needs of the individual. For instance, the safety goggles must be optically suitable and fit the heads of the workers. The glasses should be unbreakable. In short, all protective equipment must be fit for use.

Some industrial plants in Shanghai are equipped with goggles, masks, and uniforms, but the workers do not use them. Such a situation should be studied. We should above all determine whether this equipment is of pratical value (e.g., eyeglasses must be optically suited to the user). Protective devices unsuited for use can cause discomfort and thus lower the efficiency of the workers. We should not blame the workers for not using their protective devices. Instead, we should discuss with them and improve the safety devices.

D. Clearly Defined Safety Code With Fewer Prohibitive Phrases

The safety code applies to every worker. It should be adequately written. It is wrong to use prohibitive clauses or phrases such as the commonly used "Cleaning Machine Tool While in Operation Is Not Allowed," "Installing New Belt Prohibited," and "Smoking in Workshop Forbidden."

The mistake of these posters is obvious. They fail to indicate when the machine tool should be cleaned, who is responsible for the installing of a new conveyer belt, and where smoking is permitted. As has been shown in studies of industrial accidents, these negative posters are not effective.

Safety posters should be informative, pointing out what should be done rather than what should not be done. For instance, "Clean Machine Only When It Is Entriely Stopped" and "Smoke in Room X only." Safety slogans should be based on real circumstances. Avoid the use of warning phrases and of frightening pictures (such as skeletons and disfigured bodies) since these pictures may produce fear and nervousness. A brief explanatory note should be attached to the poster to warn against hazards caused mainly by negligence.

III. TECHNICAL SAFETY MEASURES USED IN THE SOVIET UNION

The study of the causes of industrial accidents is essential for the improvement of safety. In the Soviet Union, a very rigid system has been adopted for the reporting of industrial accidents. In the report on any accident the management must analyze the causes of the accident, propose remedies, and give the date by which the proposed measures are to be worked out. The chief engineer is responsible for supervising the execution of the measures.

One should not use vague terms in assigning blame for accidents. Nor should one use punitive methods to prevent accidents. Punishment is distracting and therefore misleading. The purpose of the study of the causes of accidents is to prevent accidents. Here is an illustration:

An unskilled worker was assigned to help a crane operator lift a heavy load. After he finished this work, he was not called back to his regular job (since it was only 15 minutes before the break). He roamed about the workshop and was curious about two chains attached to the crane. He pulled one chain and the crane moved forward along the track. He was frightened, so he pulled the other chain, hoping the crane would stop. The arm of the crane went up. When the crane stopped after it reached the end of the track, its arm continued to climb. The chain broke and hurt a nearby worker.

A careful study of this case will show that the ignorance of the worker was not the cause of the accident. The actual cause was that (1) the work of the plant was not very well organized, with the result that some workers could find time to roam about in the workshop, and (2) the crane had no automatic control devices.

Operation will be safe and production will be increased if the executives and engineers study each accident carefully and devise adequate preventive methods.

A. Teach the Workers Safety Lessons

In the Soviet Union, workers are urged to combat industrial accidents. Safety instruction in the Soviet Union includes three phases: (1) training before employment, (2) on-the-job training, and (3) a regular training system.

Brief training is given to workers before they are employed. The safety code and other regulations related to safety are explained to them with the help of charts and diagrams. This enables the workers to understand the nature of the shop and to obey regulations. At the end of this orientation course, a certificate is issued to the worker to be carried to work.

On-the-job training is provided by the manager of the workshop, who gives operating instructions to each worker. He supervises the worker daily, making him familiar with the correct work procedure.

The regular training system takes the form of report and interview. The individual making a report must be able to summarize the operational procedure and answer questions. Interviews are held in the workplace. The workers are told of the correct methods of operation, the consequences of incorrect methods, and the significance of industrial safety. They are encouraged to speak frankly in these interviews, so that the interviews will produce the desired effect.

IV. INDUSTRIAL SANITATION AND THE PREVENTION OF INDUSTRIAL INJURIES

A. Rules on Sanitation

To maintain the health of the workers in one area, the following rules should be observed:

1. The dining hall should not be located near the workshop. Mouth, nose, and hands should be washed before and after dinner. Foods should contain the essential vitamins. The utensils used in the dining hall and kitchen should be kept clean. The kitchen and dining hall should have apparatus for exterminating house flies. Drinking water should be boiled and clean. A number of drinking fountains should be installed.

2. There should be a sufficient number of bathrooms and showers.

3. Dormitories and dwelling houses should be kept clean and should have adequate air circulation.

4. Toilets should be kept clean at all times and should be deodorized. House flies in the toilets should be exterminated. There should be a sufficient number of toilets for men and women.

5. Workers should wear work clothes at work and keep them clean. If necessary, the management should provide the workers with masks, gloves, mouth coverings, and protective guards for the body. The management should provide clothes closets near the workplace so that workers may change their clothes.

6. There should be a number of rest rooms. Recreational facilities are also necessary, especially for women workers.

7. Chairs should be placed in the workplace so that the workers can take a rest, provided that the location of the chairs does not obstruct operations.

8. Workers should be given instruction in first aid. They should be told of the dangers of various machines and materials so they may be cautious in using them.

9. Industrial health education may be carried on in the form of posters, pamphlets, slogans, displays, and movies.

B. Types of Occupational Diseases and Their Prevention

Occupational disease means the illness of a worker resulting from his special kind of work, for instance, lead poisoning of printers and phosphorus poisoning of match workers. However, not only a special trade, but general working conditions can also impair the health of the worker.

The environmental factors which contribute to occupational diseases include excessive humidity and temperature, poisonous metals or chemicals, and miscellaneous environmental factors such as insufficient sunlight, sound or motion vibration, low or high atmospheric pressure. Abnormal working conditions, including long working hours and improper working posture, also cause occupational diseases. Personal factors of importance in occupational diseases include the age, sex, nutrition, and physical fitness of the individual.

There are four classes of occupational diseases: poisoning from inorganic substances, poisoning from organic substances, skin diseases, and dust diseases.

C. Poisoning From Inorganic Matter

Lead poisoning is the most common occupational disease. Other common diseases under this heading are phosphorus, mercury, arsenic, manganese, zinc, nickel, and cadmium poisonings. They occur when the metal is inhaled or when it penetrates into the body through contact. The seriousness of this kind of disease varies with the nature of the metal involved. Here we shall discuss only lead poisoning.

Lead poisoning occurs when lead dust or a liquid lead compound enters the body through the respiratory or digestive organs or the skin. After entry, the lead may stay in the body, disappear, or give rise to symptoms of poisoning such as the appearance of blue lines, indigestion, changes in blood circulation, paralysis of the wrist and finger muscles, cerebral diseases, and general weakness. Lead poisoning is likely to occur when the amount of lead in the air reaches 5 milligrams per 100 cubic meters of air or when the air contains every day for 2 years 2 milligrams of lead per 100 cubic meters. Young workers and women are most susceptible to lead poisoning.

Lead poisoning occurs frequently in the following occupations: lead melting, lead-pipe installing, ship dismantling, printing, canning, occupations requiring physical contact with molten lead, the manufacturing of white lead, porcelain painting, and shipbuilding.

Measures to prevent lead poisoning are: (1) better ventilation, (2) high humidity in the air, (3) the use of a mouth mask, (4) regular physical checkups, and (5) keeping the dining hall at a certain distance from the workrooms.

D. Poisoning From Organic Materials

Carbon disulfide, aniline, and benzene are common chemicals which can cause poisoning.

Carbon disulfide, a liquid with a very strong odor, is a solvent used in the production of rubber, nylon, fats, and insecticides. Adequate ventilation can prevent poisoning from carbon disulfide.

Benzene is a solvent used in the production of rubber and fats. Its poisonous effect depends on how much of it evaporates into the air. Air containing 200 parts benzene per million parts air will cause anemia. The symptoms of benzene poisoning are headache, dizziness, lack of appetite, and weakness. Adequate ventilation can prevent this type of poisoning.

Aniline is a by-product from the manufacture of dyes. It can be obtained from ammonia and nitrates. Air containing one part aniline per one million parts air becomes poisonous. It can destroy the red blood corpuscles. The symptoms of aniline poisoning are headache, redness of skin, vomiting, and weak pulse. The body absorbs more aniline at high temperatures. Nitrate-base aniline is more poisonous than ammonia-base aniline. Measures to prevent aniline poisoning are adequate ventilation, sufficient clothing, shorter work hours, and frequent bathing.

The three groups of organic chemicals which may cause occupational diseases are as follows:

1. Chemicals which may poison the blood by depriving it of its oxygen, such as carbon monoxide, furnace fumes, coal gas, and hydrocyanic acid.

2. Stimulants varying in their poisonous effect according to their density, such as ammonia, chlorine, sulfur dioxide, hydrogen sulfate, and carbonyl chloride.

3. Poisons like naphtha, petroleum, benzine, trichlorethylenes, and benzol.

E. Occupational Disease of the Skin

Skin disease is a common occupational disease. The principal skin diseases include anthrax, tetanus, glanders, eye diseases, and other bacterial diseases. Skin diseases result from the irritation caused by acid, alkali, fats, or any poisonous solution.

Measures to prevent occupational diseases of the skin include: (1) separation of workplaces producing irritable chemicals from living quarters; (2) use of protective equipment such as clothes, masks and gloves; (3) installation of a ventilation system in workrooms where there are irritating gases, fumes, or dust; (4) application of protective cream on the skin; and (5) avoiding the use of stimulants.

F. Occupational Disease Caused by Dusts

Dusts which cause occupational diseases may be of animal, vegetable, or mineral origin. Hair and feathers are not poisonous in themselves except when they carry bacteria.

Vegetable dusts include those from the useful plants like hemp, flax, cotton, hay, plant stalks, husks of cereal crops, timber dust, and bark. They are harmful to the respiratory organs. The inhalation of excessive vegetable dust accounts for the breathing difficulties of the workers in a cotton gin and the chronic cough of those working in a textile plant.

The inhalation of an excessive amount of mineral dust into the body may create a harmful reaction in the respiratory system, as with calcium dust, or in the reproductive system, as with quartz and asbestos dust, which may produce serious consequences. In some cases the dust does not produce harmful chemical reactions in the body, as with coal dust.

G. Classification of Occupational Diseases

1. Diseases due to incorrect work methods or habits

Overwork produces paralysis (stenographer, telecommunications worker, textile worker), nearsightedness (engraver, watchmaker), swollen lungs (glassworker), irregular menstruation (women textile worker), corns (foundry worker), and headache (telephone operator, store clerk).

Insufficient exercise produces, indigestion (office worker, scholar, clerk).

Incorrect posture produces spinal curvature (foundry worker, office worker), varicose veins (textile worker, store clerk), lung pneumonia (canning worker), and flat feet (textile and wire workers).

Irregular work schedule produces insomnia (night worker).

2. Diseases due to poor working conditions

Extreme temperature produces heat stroke (furnace worker, miner), and frostbite (farmer).

Rays produce eye inflammation (welding worker), inflammation of the lung (foundry worker, glassworker), sterility (X-ray worker), swollen muscles (worker in a phosphorescence plant) and vibrating eyeball (miner).

Caisson disease is common among drivers.

Sound vibrations produce hearing difficulties or deafness (shipyard worker, textile worker, and hammer operator).

Vibration produces pneumatic fingers (miner, road construction worker, driller operator).

Poisonous gases lead to poisoning, especially among chemical, metallurgical, and mining workers.

Dusts produce miners' lungs (miner, quarry worker, porcelain worker, grinding-wheel operator), breathing difficulties (carpenter, textile worker), and dust poisoning (dye worker, battery worker)

Poisonous liquids produce ulcers (textile worker), skin diseases (painter, pharmaceutical worker), and poisoning by poisonous liquids (such as carbon dioxide).

Bacteria lead to parasites in small intestine (farmer, coal miner), and contagious anthrax (wool or animal-skin processer).

H. Causes of Industrial Accidents

The causes of industrial accidents vary. The speed of performace, working conditions, psychology and health of the workers, and unexpected factors are all able to cause accidents.

Causes of accidents, in order of frequency, are (1) handling of objects, (2) falling objects, (3) machines and tools, (4) vehicles, (5) falls and (6) dangerous materials. Accidents in the handling of objects occur when the workers are physically tired or when the objects are unusually heavy or unwieldy. Accidents of this kind are not very serious. Objects fall frequently and may give rise to fatal consequences, and it is not uncommon that workers fall from stairs, elevated platforms, or windows. Machines involved in accidents are cranes, elevators, compressors, and lathes, among others. Vehicles include automobiles and trucks. Dangerous objects involved in accidents are mostly heated liquids, molten metals, and heated solid substances. Many accidents involve poisons and explosives.

1. Environment -- Generally speaking, the number of industrial accidents which occur at night is double those occurring in the daytime because lighting is poor at night. Injuries are frequent in plants where lighting is poor. In addition to lighting, speed of operations, experience,

working hours, and adequacy of supervision are all factors involved in industrial accidents. Poor visibility and reduced muscle sensitivity account for the high accident rate at night.

Inadequate heating also contributes to industrial accidents. The accident rate tends to increase when the temperature drops to 48 degrees Fahrenheit. Accident rates in mines are attributed to unusually high or low temperatures.

2. Individual health -- The mental health, age, personal habits, and physical strength of the worker are the personal factors that determine the frequency of industrial accidents. The accident rate of physically and mentally incompetent workers is three times that of competent workers. Males are more prone to have accidents than females. Male workers between the ages of 15 and 19 account for 20-25 percent of the total number of accidents among workers. This is because young workers are mostly inexperienced and unskilled. The accident rate of student workers is especially high. A worker older than 20 is less susceptible to injuries. Workers above 64 years of age account for only 1.6 percent of the total number of accidents.

Older workers need more time to recover from injuries resulting from industrial accidents. Thus the time lost from accidents involving older workers is greater than that from accidents involving younger workers. This is also because older workers are more exposed to industrial fatigue than younger workers despite the fact that older workers are more skilled.

The relationship between accidents and length of service (indicating work experience) may be demonstrated by the following survey made by Chancy and Hanna.

Length of Service (in years)	No of Workers	No of Accidents	Accident Rate [base not given]
.5	512	57	111
.5 - 1	278	29	104
1 - 3	357	31	87
3 - 5	637	27	42
5 - 10	814	16	20
10 - 15	470	4	8.5
15	459	0	0

The table shows that the more skillful the workers are, the less susceptible they are to industrial accidents. In other words, workers with long service are great assets to an industrial plant.

Wieland has pointed out that industrial accidents are due mainly to decline of work efficiency, fatigue, mental depression, and inability to respond to the work. Monotony of work, lack of interest, and uncomfortable surroundings (such as glare and noise) are also contributing factors. Personal factors, including habits after working hours and family relationships, may be involved in industrial accidents.

Fatigue is one of the principal causes of industrial accidents. After a survey of 50,000 cases of industrial accidents in 47 large plants, Vernon concludes that the number of accidents for those working a 75-hour work week is 2 1/2 times that for those working a 65-hour work week basis. Daytime accidents are caused mainly by the accelerated speed with which the work is performed. Accident rates vary with industries. A list of industries in order of their susceptibility to industrial accidents is as follows: cotton textiles, metals, shoe manufacturing, woolen textiles, rubber, glass, and printing. The cotton textile industry stands at the top of the list with the greatest number of injuries recorded.

3. Psychological factors -- The psychology of the workers is also an important element in industrial accidents. In promoting industrial safety, we should provide safety guards to prevent accidents during operations. This is why many large factories set up safety clerks.

Experts have found that accidents are not caused merely by carelessness or negligence. The fact that under the same working condition one group of workers has more accidents than another indicates that accidents are probably caused by personal factors, including those inherited, mental illness, or muscle diseases.

Messrs Green, Wood, and Wood employed statistical methods for the study of industrial accidents. They placed industrial accidents into three groups on the basis of three distribution theories: (1) random, (2) biased, and (3) uneven distribution theories. Most accidents belong in the uneven-distribution category. The uneven distribution of accidents includes those accidents which occur at one time but which recur at a different time. There are more such accidents than the random or chance accidents. A study of different types of injuries shows that some accidents tend to repeat, and that a worker who is susceptible to accidents in one factory is also susceptible to accidents in another.

Accident frequency can also be traced from psychological tests. According to experts, 25 percent of the ordinary workers have neurotic symptoms such as emotional upset, oversensitiveness, fear, lack of power to concentrate, and other symptoms of maladjustment which give rise to industrial injuries.

I. Prevention of Industrial Injuries

Most industrial injuries have personal rather than environmental causes. Personal causes fall into three groups: (1) mental instability, such as dislike of the job; (2) physical unfitness, and (3) the particular nature of some workers who are more susceptible to accidents. It is therefore necessary to examine the prospective workers carefully before they are hired. Furthermore, workers should be given training in industrial safety.

Environmental factors contributing to accidents include working conditions, the length of working hours, the nature of work, room temperature, and illumination. Thus, any safety measure must take into consideration the various aspects of industrial accidents. Safety devices such as guards attached to the machines are effective. But the most effective way to prevent accidents is to improve the working conditions and to teach the workers better techniques.

Educational slogans are very useful in safety promotion. They should be posted in workplaces or passages so as to attract the attention of the workers. The contents of the slogans should be changed periodically so that they may capture the interest of the workers. Words used in the posters should be simple and easy to understand. Workers should be encouraged to organize safety committees for the promoting of their welfare.

Proper protection from dangerous machinery is necessary for the prevention of accidents. This consists of guards or shields covering machines in whole or in part. Workers should wear suitable clothes which will not easily be caught by moving machines. Workers in chemical plants should wear specially made uniforms or gloves as a protection against corrosive chemicals.

J. Treatment of Injuries

The treatment of injuries from industrial accidents has been greatly improved in the past 20 years, since the severe consequences from wounds have been recognized. In a plant with few workers, the installation of first-aid boxes in the workplace is sufficient. But a large industrial plant should have emergency sick rooms and nurses.

If the patient suffers from broken or dislocated bones, he should be sent to a hospital with surgical facilities. Surgical hospitals should be set up in industrial areas. If that is impossible, several industrial plants should jointly hire a surgeon to take care of emergency cases.

V. SOCIAL INSURANCE FOR WORKERS

A. Meaning of Social Insurance

Social insurance, a government measure for the protection of the workers' life, has become very complex. The definition of the term "social insurance" varies from country to country. Some believe that social insurance is a government policy for the protection of workers and people of lower social classes from various hazards prevailing in modern industrial life. Others define social insurance as a government action to diminish the uncertainties in the daily life of workers. Another school of thought is that social insurance is an institution which distributes disability payments evenly among a group of people on the basis of cooperation and in accordance with the law of the state.

The following contingencies constitute grounds for social insurance: (1) temporary inability to work as a result of unemployment, occupational disease, illness, or pregnancy; (2) partial or complete loss of earning capacity because of disability, illness, or old age; (3) unemployment as a result of the diminished demand for labor; (4) when death gives rise to various expenses including funeral expenses and family support. All these contingencies are covered by insurance as required by the government.

An accident covered by insurance must satisfy four conditions: (1) it must be the result of a hazard; (2) a majority of the people must be exposed to the hazard; (3) the value of the loss from the accident must be measured with relative accuracy and (4) the accident must constitute a threat to the prospective policyholder. Conditions qualified for inclusion in an insurance system include illness, injuries (accidental), birth, disability, old age, and unemployment (except in a socialist state).

Germany was the first country to introduce social insurance. Social insurance originated in a school of thought which advocated a socialist policy. This school was represented by Wagner, Schmoller, and others who were influenced by Winkelhech and Schaffle. They believed that maintenance of the economic system in working order is the responsibility of every member of society. The suffering of the economically weak is not their own fault but the fault of society. Thus relief and support of the poor is the duty of all members of society. Furthermore, the modern economic society is a complex organism in which the interests of all members are interwoven. The suffering and discontent of one group or class is fatal to social stability, which requires each individual to be economically secure. This security can be attained by a social insurance system. The principle of ordinary insurance is to distribute the losses of one individual among the whole society or group. This principle also governs social insurance.

Germany passed the Compulsory Health Insurance Act on 15 June 1883, the Accident Insurance Act on 6 July 1884, and the Old Age Insurance Act in 1889. Similar measures followed in the Dutch-speaking countries, continental Europe, the Latin countries, England, and America. Finally the social insurance system was adopted by the Far Eastern countries. Within 30 years after its introduction, social insurance, in the form of hospitalization insurance, accident insurance, and disability and old age insurance, was adopted by all the principal powers in the world.

B. <u>Function of Social Insurance Under Two Different Economic Systems</u>

Social insurance is practiced in the Soviet Union as in other countries. However, we must point out here that the social insurance practiced in the Soviet Union is quite different from that practiced in other countries.

Social insurance was primarily a policy utilized by the capitalist countries to slow down social struggles and to checkmate socialist revolution. Germany under Bismarck was the first country to introduce compulsory social insurance. It was followed by other capitalist countries. Their social insurance was implemented for the purpose of sustaining and developing capitalism. They were disappointed, however, for social insurance could not rescue capitalism from crisis. Social insurance in the Soviet Union on the other hand is growing rapidly. This indicates that social insurance has entered a new phase of development as a result of the socialist victory.

The social insurance system in the Soviet Union differs from that in the capitalist countries not so much in structure as in purpose.

The social insurance system in the capitalist countries serves on the surface as charity to the poor proletariat. But actually it is used as a means to paralyze the revolutionary role of the proletariat and to maintain the rule of the bourgeois class. In the Soviet Union, social insurance serves the needs of the working people and becomes an instrument to protect the interests of the working people. Various hazards such as illness, injury, disability, old age, and death are always present in daily life. Those who suffer from any of these, including their dependents, should receive proper relief and compensation so that every member of society may be fully protected and the ideal of social security may materialize. One of the measures that bring about social security is social insurance.

Furthermore, social insurance in the Soviet Union has become one of the methods to encourage the working people to do their best. It has produced magnificent results. Under the socialist economic system, social insurance constitutes a form of social reward. To obtain this reward and to receive a greater amount of what they have produced, the working people must continue to improve their efficiency and to boost output.

C. Payments to Workers Under USSR Social Insurance System

The following payments are made to workers in cash:

1. Short-term payment -- This covers temporary disabilities due to injuries from work (including occupational diseases), illness, maternity, illness of one's dependents, or quarantine. This type of payment is handled by trade-union organizations.

2. The beneficiaries of old age, disability, and life insurance are placed in four groups according to the nature of their work:

a. Those working underground or engaged in dangerous and strenuous work;

b. Blue- or white-collar workers employed by the mining, construction, electrical engineering, metallurgical, rubber, or transport industries;

c. Blue-collar workers not employed by the above-mentioned industries, white-collar workers in production and health service, and personnel in mining or manufacturing plants;

d. Other white-collar workers not included above.

3. Miscellaneous allowances -- A mother receives an insurance payment and family allowances during her maternity leave (amounting to 35 days before and 42-56 days after the birth). In addition, she receives 120 rubles at the time of delivery and 180 rubles as a milk subsidy. A needy person may receive more on the recommendation of the factory committee.

Another allowance is the funeral allowance. Funeral allowances are given to the dependents of the following groups of workers:

a. Workers in state enterprises;

b. Workers employed by privately owned enterprises or farms;

c. Beneficiaries of social insurance policies; and

d. Students or trainees in colleges, professional schools, or training classes who were previously workers.

D. Characteristics of the USSR Social Insurance System

If we know something about the social insurance system under the capitalist system, we will find there are many special features in the Soviet Union's social insurance system.

1. Types of insurance -- A majority of the capitalist countries have unemployment insurance. Since the Soviet Union has eliminated unemployment, unemployment insurance was abolished in 1930. But it has other kinds of insurance, including hospitalization, injury, maternity, disability, life, and family insurance.

2. Organization -- Two points should be mentioned in this respect:

a. The social insurance system in the Soviet Union is for the most part handled by the trade union in contrast with government administration in capitalist countries.

b. In most capitalist countries, the social insurance system covers all those who are employed regardless of the type of employment, whereas the Soviet Union uses the occupational insurance system in which the workers in each industry have their own insurance funds committee, consisting of the insurance agent.

3. Coverage -- In the Soviet Union, almost all employed workers are protected by social insurance. In a capitalist country many restrictions bar some working people from being covered by insurance.

4. Financial Aspects -- Two points should be noticed:

a. The cost of insurance is borne by the employer (the state in most cases), workers do not have to pay. Insurance costs are included in cost of production. In a capitalist country, workers are compelled to share part of the cost of insurance. This is not just.

b. The cost of insurance varies with the industry since the hazards involved vary from one industry to another. In a capitalist country, all the insurance rates are the same regardless of the nature of the industry although the rates vary occasionally with the degree of hazard within the industry.

5. Seniority -- Under the Soviet Union's social insurance system, the amount of insurance a worker receives varies with the length of

service. This helps to reduce the mobility of workers and thus contributes to increased production. Furthermore, there are provisions to give special benefits to workers who have given distinguished service to the state.

VI. SOVIET LEGISLATION ON WORK HOURS AND WAGES

A. Regulations on Work Hours

In formulating its regulations on working hours, the Soviet Union adheres to two principles: (1) the people are entitled to leisure time and to use it freely without interference, and (2) the work hours of the people should be properly organized so they may efficiently contribute to social welfare.

The Soviet Union's laws compel the workers to make the most efficient use of their working hours for the increase of social wealth. State enterprises and public institutions are responsible for eliminating the causes of time wasted and for creating conditions necessary for the continuous functioning of the enterprises.

An adequate number of working hours is stipulated in USSR labor laws. On 28 December 1938, a resolution approved by the People's Soviet, the Central Committee of the Soviet Union, and the Central Committee of the Trade Unions declared: "As demanded by the state and supported by the working class, the length of work hours must be observed and the workday must be a full 8-, 7-, or 6-hour day as provided by law."

Under the Soviet Union's legislation, the workers must render their service for the full amount of time stipulated in the laws. On the other hand, the employer must not order his workers to do overtime work except under special circumstances in accordance with the laws.

The service rendered by a worker during working hours includes his principal work and auxiliary work (such as cleaning the machines). Such auxiliary work may or may not be included in his official capacity as a worker. It may be paid on a piecework or time basis. Regardless of such distinctions, both employer and employee must respect the requirements on the duration of working hours as stipulated in labor laws.

The regulations on working hours apply also to the workers who do their work at home. This is indicated by the fact that their wages are calculated on the amount of work they can do in an 8-hour period.

B. Working Hours

In 1940, the Soviet Union adopted a 7-hour workday system in manufacturing, transportation, communications, and public utilities, and an 8-hour workday system in lumbering, construction, merchandise retailing, agriculture, industries subject to seasonal factors, and part of the transport industry (except some railways adopting the 7-hour system.) A 6-hour system was adopted in industries which require strenuous exercise or involve hazards. This 6-hour work system applied also to young workers between the ages of 16 and 18.

During World War II, the 6- or 7-hour system was considered inadequate. On 26 June 1940, the Presidium of the Supreme Soviet extended the previous 6- and 7-hour workday systems to 7- and 8-hour systems for all workers in state enterprises, public utilities, and cooperatives. The workday for workers over 16 years of age was extended from the previous 6 hours to 8 hours.

Nightworkers are required to work not longer than 7 hours between 2200 and 0500 hours. They receive higher wages.

Workers in the following industries have a shorter workday ranging from 4 to 6 hours. These industries are the metallurgical (including iron and steel, aluminum, magnesium, copper, nickel, lead, zinc, rare metals, gold, and white gold), petroleum, local power transformer stations, and benzene, glass, paper, tobacco, and asbestos industries.

C. Overtime Work

Overtime work is generally prohibited in the Soviet Union except in special cases. According to law, a worker cannot work 120 hours of overtime in one year, or 4 hours in 2 consecutive days. Within this limit, overtime work is permissible for meeting defense needs, prevention of industrial hazards and dangers, assuring a continuous supply of water, uninterrupted functioning of dams, transport, postal service and telecommunications, or counteracting losses in industry due to unexpected work delays.

The wage rate for overtime is 50 percent higher than the regular rate for the first 2 hours and 100 percent higher thereafter. Before workers may be required to do overtime work, approval must be obtained from the wage-adjustment committee within the industrial plant.

A female worker is not compelled to work overtime beginning the 4th month of pregnancy and during the first 6 months she nurses her infant. Workers who are disabled, tubercular, or under 16 years of age cannot be assigned to overtime work without approval by the People's Committee of the Soviet Union.

Since the end of the war, the overtime work system has been gradually replaced by a regular work system.

D. Rest Periods

The Soviet Union's regulations on working time deal with the number of working hours, as well as rest periods, schedules of rest periods, and duration of the work week.

There are daily, 2-day, and weekly rest periods.

Each worker is entitled to a break after about 4 hours. The duration of this break varies with industries and is stipulated by the Collective Contract Bureau of the Ministry of Interior. A minimum rest period lasts 30 minutes. It is 2 hours at maximun. Time spent for resting is not counted as part of the working hours.

Breast-feeding mothers are given at least 30 minutes of rest every 3 1/2 hours. They receive pay for the rest periods.

The duration of a day's rest period, including time for meals, must be equal to at least two times the working hours. For instance, a man who works 8 hours a day should have 16 hours of rest periods including mealtimes.

In addition to week-end holidays, there are the following legal holidays: (1) 22 January, commemorating the Massacre of 9 Janurary 1905 and in memory of Lenin; (2) 1 and 2 May, celebrating the unity of international labor; (3) 7 and 8 November, celebrating the October Socialist Revolution; (4) 5 December, celebrating the pronouncement of the Constitution of the Soviet Union; and (5) two holidays added since 1945 by the People's Soviet -- 1 January and 9 May celebrating New Year's Day and the victory over the German fascists.

It is not permissible to work during these legal holidays. But this does not apply in industries or institutions which must provide uninterrupted service to the public. The rate for work during these holidays is twice the regular wage rates.

E. Vacation

Legislation on vacations guarantees the right to rest. The vacation system becomes a major consideration in determining the number of employment and the distribution of duties.

According to the law, a worker who has been working consecutively for 11 months in the same plant or office is entitled to a regular vacation period. A worker who has been in service in the same industrial plant or office for a certain number of years will have a longer vacation.

Since the Soviet state respects the right of its workers to rest, it gives vacation with pay. The wage rate during the vacation period is equal to the average rate earned by the worker in the 12-month period preceding the vacation.

Twelve days of annual leave is given to each worker. Workers under 16 years of age are entitled to one month of annual leave. Some workers receive longer vacation periods, 24-48 days for science workers and 24 days for some cultural workers and timber workers. A still longer vacation is given to those doing dangerous work. Additional vacation leave is usually given after the regular vacation, and varies from 6 to 12 days.

A worker who works and studies at the same time and who has to take an examination for graduation is given additional leave ranging from 15 to 20 days.

F. Principles Governing Wage Rates

The phrase "from each according to his ability and to each according to his work" stipulated in the Soviet Constitution serves as the basis for the Soviet Union's wage system. As stipulated in Article 122 of the Constitution, women are entitled to the same wages as men. The wage rate cannot vary with age. A youth doing the same work as an adult should receive the same wages.

The variation in wages comes from the skill of the workers and depends on whether the work is easy or difficult.

In principle, the Soviet state determines the compensation for workers on the basis of the quantity and quality of their work. In other words, the efficient workers receive an incentive wage. Thus a wage scale is formed. The more difficult the job, the higher the pay. Wages are determined entirely by the productivity of labor.

G. Wage Schedule

The wage schedule gives the pay scales corresponding to the skills required for various types of work and coefficients showing the relationship of the basic wage to other wages. The basic rates on piecework or on a time basis vary with industries. The piecework rate for the same job generally brings higher earnings than the time rate.

There are from seven to nine pay scales in a wage schedule. The coefficient of a scale times the basic wage scale equals the actual wage for that scale. For instance, the wage schedule for the construction industry has seven scales. The ratio of the first scale to the seventh is 1:3.6.

H. Wage System

The wage system in the Soviet Union makes a distinction between different skills. It also distinguishes between labor cost and labor output.

The piecework system is followed by the Soviet Union. Either of the following two methods may be chosen for determining wages: the daily production rate divided by the daily standard output or norm, or the time required for the production of one unit of output times the hourly wage rate. Under an 8-hour system and provided that working conditions are satisfactory, a piecework wage system is not detrimental to the health of the workers.

There are time wages and incentive wages, in addition to the piecework system. The time wage is determined by the amount of time spent on the job. The incentive wage is determined by both time and output. A pure time-wage system is rare in the Soviet Union since it provides no incentive to the workers. The incentive-wage prevails in combination with the time-wage system.

I. Minimum Wages

The labor laws provide that wages must not be lower than the minimum wages stipulated by the government. Actually, the wages paid by most industrial organizations are much higher than the minimum wage.

The labor laws of the Soviet Union have other provisions for minimum wage rates. For instance, the wages of a pregnant woman doing light work is equal to her average earnings in the past. A worker assigned to a different job because of necessity is paid according to his previous earnings. If he is doing a lighter job, he will be paid according to his earnings in the 12 days preceding the transfer. Loss of time due to the fault of the worker will cost him half or two-thirds of his wages.

J. Wage Administration

In some cases the type of wage system to be used, the basic rates, and other detailed regulations are determined by government laws and orders. But in other cases they are determined by the manager or by a contract between the management and the union. For instance, the wage system for coal mining, automatic machinery, and textile industries is specified by the government.

Although the wage system, including basic rates, schedules, and detailed regulations, is determined by the government's policy-making bodies, it is administered by the managerial personnel of the plant concerned. At one time, the manager ascertained the norms to be used for piecework wages, but he has not had this authority since the outbreak of the Russian war of self-defense.

The trade union plays an important role in the administration of wages. It participates in the preparation of wage laws and in the determination of basic rates. It has authority over the standard wages and supervises the payment of wages. It can protest any action of the manager that violates the wage regulations. The union also has special agencies for handling wage cases.

Part 3. STUDY OF THE PRODUCT OF LABOR

I. SIGNIFICANCE OF LABOR STATISTICS

A. Purpose of Labor Statistics

The chief purpose of industrial statistics is the study of the product of labor (industrial product). Its secondary purpose is to study the working conditions necessary for the production of a given amount of goods.

Labor is a factor of production. Together with tools, labor becomes the creator of use value, as well as of exchange value.

As industrial technology has advanced, the relationship between man and machine has gradually changed. The machine has replaced man in many instances where man previously played the leading role. In fact, the replacement of man by machine has reached the extent in some industrial plants in which automatic machinery is extensively used that man has become solely a caretaker. However, man is still an essential factor of production, for he controls and supervises the production process even in plants which use automatic machines. Since labor plays such a decisive part in production, it is necessary to conduct a statistical study of it.

In the process of production, labor of different kinds assumes different functions. Industrial labor refers mainly to workers. But workers have varying skills, functions, lengths of service, and other characteristics. In view of the complex structure of the industrial labor force, it is necessary to make a careful study of its composition.

By studying the history of an industry we can determine quantitatively the changes in the composition of its labor force. However, our attention should be focused on the trends in skilled labor.

Another goal of labor statistics is to determine the degree of utilization of manpower resources. We should study the distribution of manpower resources among the industries so as to organize an efficient production system.

Labor statistics also includes the study of production norms and wage standards. These will be dealt with in separate sections below.

B. Classification of Industrial Labor.

Industrial labor consists generally of five groups:

1. Workers -- A worker is the person who directs his effort to an object, transforms it into something new, and takes care of the means of production.

2. Apprentices -- An apprentice is a person who learns the techniques necessary for becoming a worker. He is not a full-fledged worker; he is only a student worker or trainee.

3. Technical personnel -- This refers to those responsible for technical guidance in the production process. They play an important role in production. A person may become a technician regardless of his education if he has sufficient experience.

4. Staff members -- These are any persons such as executives, and economic and general service personnel, who work in a factory but are not directly concerned with the production process.

5. Service personnel -- These include guards, cleaning workers in factories, offices, and affiliated establishments (not for production), cooks, kitchen helpers, and service personnel in offices (messengers and office boys).

Such a classification is the preliminary step in the study of the composition of industrial labor. A thorough study of industrial labor should include an exhaustive classification of labor on the basis of the production process. This classification places all the workers in two groups: shopworkers and nonshopworkers. Among the shopworkers are workers of different skills.

Another classification considers workers as production workers or auxiliary workers. Production workers are those who take part in the operations directed toward the object, while auxiliary workers undertake supplementary work not directly concerned with the object.

C. Measuring Labor Time

Labor is used in varying degrees which can be expressed in quantitative terms. There are many causes which account for the failure to utilize fully the available labor power. To find these causes, it is necessary to measure the intensity or extent to which labor is utilized.

Measurement of labor utilization has special meaning to the workers. We should establish various standards by which labor power may be measured. To do this, we must contact a statistical survey of how labor is utilized.

The problem of finding a measure of labor is that of ascertaining the amount of labor which has been consumed in the process of production. Karl Marx has given us instruction on this problem. He said, "The quantity of labor is measured in terms of the duration of work or the length of working time. Working time in turn is expressed in terms of time units such as hour and day" (Karl Marx, Capital, Volume I, page 40, 1937 edition).

Marx called the amount of labor expressed in terms of time units the external labor quantity. These time units (man-hours, man-days) are used as standard measures in labor statistics.

A man-day is the amount of work done (whether completed or not) by a workman in one day. The concept man-day does not concern itself with how much the workman has done in the course of the day. In fact, a worker sometimes works only part of the time in a day. He is idle the rest of the time for various reasons. On the other hand, a worker may put in extra time after he finishes a day's work. This shows that the man-day is not an accurate measure of labor power. The man-hour is a better measure of labor. It does not include idle time, time lost from work stoppage, late arrival, or early departure.

The man-hour is not a perfect measure of labor, for part of the time within the hour is often wasted. According to a regulation determined by the Central Statistical Bureau, the Central Committee of the Communist Party of the Soviet Union, and the Central Executive Committee of the Trade Unions of the Soviet Union, a worker is considered absent from work if he arrives 20 minutes late. In this instance, the man-minute is used as the unit to measure labor provided the workshop uses a quota system and performances involved may be measured or timed.

Idle time occurs when workers are not working for some undesirable reason after they arrive in the workplace. Idle time may be a full day or part of a day.

A whole idle man-day refers to the day in which the worker receives no assignment after he arrives for work for certain reasons for which management is responsible. Such a case is rare. A man-day is also considered idle if a worker receives notice from the management that he may not expect any assignment for the day and as a result he cannot go to work. A full man-day is entered into the work record for a worker who finishes a day's work not properly belonging to his regular duty. However, the existence of such a case shows that the work is poorly organized. Thus such a man-day is treated statistically as a utilized idle man-day.

Absenteeism is also reckoned in terms of man-days. Absenteeism has different causes. The following items appear on a form used by the Soviet Union to record absenteeism:

Workers on the payroll, total absentees, on holiday or vacation leave, absent without leave, authorized leave, on leave according to law, on sick leave, on maternity leave, on week-end leave, number of workers attending but not working, and number of workers actually working.

The above is the daily attendance recommended by the Central Statistical Bureau. It shows the number of workers present or absent and lists the causes of absence.

Although the attendance record is important, it is not perfect in the sense that it does not record the working time by the hour. Sometimes idle working hours amount to a large number.

In view of this, the Soviet Union adopted a form for recording the working hours as follows:

Utilization of Working Time

Man-hours of partially idle workers

Man-hours of overtime workers

Total

Man-days of workers on duty on holidays

Absent workers

Absent without leave

Absent with leave

Absent because of other appointment authorized by law

On sick leave

On maternity leave

On week-end leave

Man-days of workers not present

Total man-days of workers present

The above table includes not only regular working days but also the extended or short (because of work stoppage) working days.

Idle time is entered in the record in greater detail by the use of the following table:

Total number of man-hours present

Actual working hours

Regular working hours

Overtime

Man-hours not utilized because of:

Illness

Maternity care

Other legal appointment

Workers below legal age

Total

Idle time

Total

Stoppage

Late arrival or early departure

Other

Two things must be entered into the time record: the amount of time utilized and the factors determining the time so utilized. The factors determining the distribution of working time should be studied carefully.

Industrial workers should work a certain portion of the week for state enterprises under the collective contracts. However, the workers are sometimes not required to work for reasons approved by law, e.g., on legal holidays, when on duty for the state, and when feeding their babies. Sometimes working time is not utilized because of poor organization (e.g., delays), or because of violations of labor discipline (absence or tardiness). We should study the various factors involved in absences. To relate the distribution of working time and the causes for absence, the Soviet Union adopted monthly and daily work journals (see Shavensky's Textbook of Industrial Statistics, Chinese translation, Section 12, Chapter 4, Volume II).

II. CLASSIFICATION OF INDUSTRIAL PRODUCTS

A. Common Character of Industrial Products

Industrial products are part of the social products created by labor. The statistical characteristics of industrial products are as follows:

1. Industrial products are either goods or services. They either have definite forms or shapes, or are productive services.

A product is something produced in the course of the operations of an industry. Not all industrial operations produce material things. The result of these operations may not be a new product but a service which may recover the lost use-value of a product or may increase the use-value of a product. Repairing is an example of the former and dyeing of the latter. Under the present statistical practices of the Soviet Union, industrial service includes the products of the workshops (including steam produced by the boilers, electric power by the power stations, and repair services offered by one plant to another). The distinction is obvious: a product is a material substance while a service is not.

Not all the goods possessed by an industrial plant are products of the plant. Raw materials which have not been worked on, fuels supplied by another plant, and tools which have depreciated are not considered products of the particular plant.

2. Industrial products are the output of the manufacturing division of an industrial plant. From this viewpoint, the output of the nonproductive divisions of an enterprise or of nonindustrial enterprises (transportation shop, planning division, affiliated farm of an enterprise) are not classified as industrial products.

3. Products which do not represent the effective results of industrial activities are not considered industrial products.

Useless products refer to those below technical standards. However, products of inferior quality or products unfit for the originally planned use are not considered absolutely useless.

4. Industrial products are the direct results of industrial activities. Accordingly, the waste and residue of production are not considered industrial products. Waste refers to the raw materials unavoidably left over in the course of production, e.g., sawdust and chips in a timber mill, iron dust in a metalworking plant, and waste cloth in a clothing factory.

Some waste products may be used as raw materials for other industrial products (e.g., scrap metals, textile waste, and leather waste for the manufacture of consumer goods, or scrap-iron articles) in the foundry. These waste products become more useful as technical skill improves. They are considered industrial products after this new use, but not before.

We must not confuse by-products with waste products. By-products are produced at the same time as the main products, and have their own use. For instance, soybean cake is a by-product of oil extraction, and coal gas is a by-product of coal distillation.

B. Finished and Semifinished Products

The completeness of a product varies with the stage of the production process. Generally, industrial products are finished products or semifinished products. Goods in process are known as unfinished products.

Finished products are those which cannot be worked on further by the plant that manufactures them. Semifinished products, on the other hand, require further processing within the plant that produces them.

Finished and semifinished products are defined from the point of view of the enterprise that produces them. Accordingly, a product which needs no further processing within the enterprise in a finished product.

Furthermore, the same product may be classified as finished by one enterprise and as semifinished by another. For instance, the pig iron produced in a steel plant is a semifinished product since it is being used for the production of steel, while it is a finished product in ironworks delivering to other plants.

C. Distinction Between Goods in Process and Semifinished Goods

The term "goods in process" is often used in industrial statistics. It refers to materials between the raw material and semifinished stage and between the semifinished and finished product stage.

It is easy to distinguish finished products from goods in process. Goods in process by definition refer to those which are incomplete. It is, however, rather difficult to make a distinction between goods in process and semifinished products. Since goods in process are also unfinished products, are they the same as semifinished products?

A simple method to distinguish between semifinished products and goods in process is to treat the products coming from the workshops (except the last or finishing workshop) as semifinished products. Goods in process include the products still left unfinished in the various workshops (including the finishing workshop). They include parts which need further processing in the same workshop and those which are still in the process of production (for instance, on the lathe's work table).

In the Soviet Union's statistical system, industrial products are grouped as finished and semifinished products only. The term "goods in process" is used only when the statistical survey is of an enterprise whose production process is very long and involves a wide range of quantitative changes.

In the present statistical system of the Soviet Union, the term "goods in process" as used in production statistics consists of unfinished goods of industrial plants which employ a very long process of production (e.g., metalworking and machine-building industries). Theoretically, goods in process should be included in an accurate statistical report, because they are the result of labor as much as any other industrial product. Also, they are economically similar to semifinished and finished products.

To introduce production planning to every workshop and realize the benefit of coordination among the workshops, it is necessary to ascertain the amount of goods in process by types of goods and by workshops.

D. Definition of Finished Products

We may consider a product finished the moment it comes from the last stage of the operation, or when it is accepted by the person in charge of finished products. We may use the moment the product enters the warehouse as a dividing line between finished and unfinished products.

The Soviet Union has adopted the second method, i.e., the acceptance method. A product is considered finished only after it is inspected and accepted by the technical inspection division. If the goods are produced on a contract basis, they are considered finished products after acceptance by the party which orders them.

This is obviously a better method. It prevents double counting of goods which may re-enter the factory for additional finishing.

Another criterion for a finished product is completeness. The need for this criterion arises when the product is composed of a great number of parts produced by different workshops. The product is considered finished only after it is assembled and tested.

Some products require a number of accessories. These accessories are indispensable parts of the products. If this is the case, the products are not considered finished unless the accessories are attached.

The following lists the requirements of industrial products as adopted by the Soviet Union in its statistical work:

1. A product must comply with the planned standards or with the standards stipulated in the invoice of the enterprise.

2. An assembled product must be complete as stipulated in the production order or contract. If the attachment of accessories is required, the product is considered finished only after these accessories are attached to it.

3. A product is considered finished only after it is inspected and accepted by the inspection department or by the party which orders the product.

III. PRODUCT STANDARD SPECIFICATIONS AND THE PROBLEM OF DEFECTIVE PRODUCTS

A. Study of Product Quality

It is of great importance to improve the quality, as well as the quantity, of products under a socialist or people's democratic economy.

The purpose of the statistical study of industrial products is to discover an over-all measure which may be used to show the general trend of the industry with respect to quality. The study is not limited to one special industry. It covers all industries. Such a study is possible only in the Soviet Union, for in a people's democratic economy private enterprises still exist.

There are many ways to indicate the quality of a product. It is extremely difficult to total all the quality indicators and express them in one measure. In some industries, the distribution of the products into various categories shows the quality scale of the industry. In other words, they use classification as a method to discover the standard of their products. Such a classification is difficult for some industries because their products possess not one, but many, characteristics. For instance, in the case of fireproof materials, the standard requirements include both chemical and physical properties. A requirement which is adequate in the examination of one product may not be adequate in the examination of another product.

However, some industries such as machine-building and other related industries) do not allow any variation in the quality of their products. They use the proportion of defective products to perfect products as a quality indicator. However, defective products are spoiled raw materials and are not finished products. The proportion of defective products thus shows only the quality of the operation or performance. It does not indicate the quality of the products themselves.

Degree of compliance with the quality specifications contained in the production order or goods invoice may serve as a criterion for the quality of the products. However, the appraisal of product quality is a very complex technical process, involving many and varied data. It is very difficult to find a common denominator to indicate quality.

We will discuss briefly the use of quality distribution as a method for the appraisal of product quality. Not all industrial plants can use this method. It can be used by industries producing daily necessities, including the textile, shoe-making, cement and brick industries. The amount of one grade of product in relation to that of another or to that in a base period (either the previous period or another specified period) serves sufficiently as an indicator of its quality. Such a comparison can furnish a common denominator of the quality of the products.

The comparison of the test results of a product and its previously fixed standard specifications also furnishes a common denominator of the quality of the product. An average figure may be obtained by comparison of the test results with the standard specifications. Sampling methods may be used if the quantity of the products is large.

Another method is based on consumer complaints, or consumer requests for a refund, adjustment, or discount. The number of consumer complaints serves to indicate the quality of the product. However, this method is not adequate, for a consumer may not protest every time he receives an unsatisfactory article, and often the consumer makes his complaint long after the goods were produced.

Another method of appraising product quality involves the study of defective products. Defective products are grouped into two categories: remediable and irremediable. Irremediable products mean a waste of materials and labor. To reclaim defective products sometimes requires the repetition of the entire production process. In other cases, only part of the process needs to be repeated.

The financial loss from irremediable products equals the production cost of these products. Under normal conditions, the management tries to utilize defective products as much as possible. For this reason, the financial loss is partially recovered by the sale of the defective products or by their use as raw materials. The loss from remediable products equals the cost of reprocessing. The combined losses from remediable and irremediable defective products constitute the total loss from defective products.

However, we must point out that such computations reveal the losses to the industry only. They do not reveal the cost of defective products to the national economy as a whole. Strictly from the viewpoint of the industry, the losses are not chargeable to the cost of production if the industry does not pay the workers for reconverting the defective products. But defective products are a burden to the national economy. Thus it is correct to set up a column in the statistical report indicating the number of unpaid man-days worked on defective products.

Next we come to ascertaining the proportion of defective products in the total. Our problems are (1) how to determine the total quantity of defective products, and (2) how to determine the relative values of the defective products.

The total cost of defective products equals the cost of reconverting the remediable products plus the cost of the irremediable defective products.

The cost of defective products may be computed on the basis of the original production cost. The cost of defective products to a particular workshop is computed on the basis of the turnover rate.

The ratio of the cost of defective products to that of the useable products indicates to a certain extent the relative value of the defective products. However, this may result in estimates either too large or too small. To avoid errors from an evaluation of the costs, it is better to compare these two sets of data on the basis of labor cost, i.e., man-hours.

Furthermore, it is advisable to distinguish factory-defective products from returned defective products. The former are defective products discovered in the factory and the latter refer to defective products returned by customers. Returned defective products indicate not only the poor quality of the products but also the failure of the factory's inspection department. To avoid overestimating the value of finished products, the value of the returned defective products should be deducted from the value of the finished products.

To launch an effective campaign against defective products, we must study the causes of the defects. We should find out what kind of defect is caused by labor and compare one type of defect with another. Thus we should put down the causes of the defects in the defect summary table (a very valuable record for the management), place these causes into categories, and make a careful study of them.

Among many causes which account for defective products are inexperience, misunderstanding of instructions, unfamiliarity with machines, causes pertaining to the layout, and accidental causes. All should be recorded and studied carefully. The workers who witnessed the occurrence of the defects should be asked to sign the record. However, the record should not be used as a basis for punitive action.

Inspection is essential for the improvement of product quality. Since the inspection and testing of all products are possible only in small enterprises, sample inspection is used by large-scale enterprises.

B. Sample Inspection

Sample inspection is in many respects better than the inspection of every item. If we can organize the samples properly, we will be able to ascertain the accuracy of and possible errors in the sampling. The bias in sampling may be corrected by enlarging the scope of the samples. Sampling inspection in the Soviet Union is known as the qualitative statistical method, and various types have been widely used.

Products of perfect quality are controlled by specifications. If there are no specifications, the products are examined for certain general technical standards derived from tests. There may be any number of specifications for a product.

The purpose of sample inspection is to determine whether the quality of the product complies with standards. It is the task of the inspectors to collect data relating to product quality, as well as to take necessary steps to eliminate defects.

An inspection team should be established for the regular inspection of products. The team may choose a day early in the month and begin the sample inspection of the products. It should compare the ratio of the number of defective products with the total number. Another such sample inspection should be made one month later. The ratio of defective products derived from the first inspection may be different from that of the second inspection and will therefore indicate that the quality of the products manufactured in the first month is higher or lower than the quality of those manufactured in the second month. The following formula will determine the difference in quality.

Assuming N (not less than 30) equals the number of products under inspection, P_1 the ratio of the number of defective products to the total number of products in the first inspection, P_2 the ratio of the number of defective products in the second inspection, and t the indicator, then: $t = \frac{P_1 - P_2}{6P}$, $6P = \sqrt{\frac{2P\,(1-P)}{N}}$, and $P = \frac{P_1 + P_2}{2}$.

In this formula, t has two values t_1 equals 1.95996 and t_2 equals 2.57582. If the result of our computation shows that the probability of t being equal or greater than t_1 is 1/20, the chances are that at least one out of 20 units of the product is defective. If the probability of t being equal or greater than t_2 is 1/100, the chances are that at least one in 100 is defective. The result using t_2 is the more reliable.

Two examples are as follows:

1. An electric light bulb factory inspected 100 bulbs. In the first inspection, 18 bulbs were found defective; in the second inspection, 12 were found defective. The t value can be derived from the formula above, as follows

$$N = 100$$

$$P_1 - \frac{18}{100} = 0.18 \qquad P_2 = \frac{12}{100} = 0.12$$

$$P_1 - P_2 = 0.18 - 0.12 = 0.06$$

$$P = \frac{0.18 + 0.12}{2} = 0.15$$

$$1 - P = 1 - 0.15 = 0.85$$

$$6P = \sqrt{\frac{2 \times 0.15 \times 0.85}{100}} = 0.05$$

Therefore, $t = 0.06/0.05 = 1.2$

The value of t, which is 1.2, is smaller than 1.95996 (t_1), showing that the results from the two inspections are not remarkably different. In other words, no remarkable progress has been made with regard to product quality since the first inspection.

2. A screw-manufacturing plant found 56 defective products out of 200 in its first inspection and 28 out of 200 in its second inspection. The t value of these two inspections is derived as follows:

$N = 200$

$P_1 = 56/200 = 0.28$

$P_2 = 28/200 = 0.14$

$P_1 - P_2 = 0.28 - 0.14 = 0.14$

$P = \frac{0.28 + 0.14}{2} = 0.21$

$1 - P = 1 - 0.21 = 0.79$

$6P = \frac{\sqrt{2 \times 0.21 \times 0.79}}{200} = 0.041$

Therefore $t = \frac{0.14}{0.041} = 3.4$

Using t_2 as the base for comparison, t equals 3.4 which is greater than 2.57582 (t_2). In other words, the quality of the products has been improved from the first inspection.

The following tables are used for recording and comparing the inspection results.

Quality Inspection Record

195X

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Defective Ratio												

Comparison of Inspection Results

195X

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Comparison with	Jan	Jan Feb	Jan Mar	Jan Apr	Jan May	Jan Jun	Jan Jul	Jan Aug	Jan Sep	Jan Oct	Jan Nov
Progress											
No change											
Backward											

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IV. MEASURING LABOR PRODUCTIVITY

Industrial achievement is determined mainly by the level of labor productivity. Increasing labor productivity means more goods produced, lower costs of production, and improved turnover of working capital.

What is the implication of a rise in labor productivity? According to Marx, "an increased productivity of labor implies a change in the use of labor which results in society's requiring less time for the production of a commodity" (Marx: Capital, Russian edition, 1935, Chapter 10, page 234).

A. The Function of Statistical Workers

The function of the statistical workers in their study of industrial labor productivity is (1) to ascertain labor productivity, (2) to compile an index for the comparison of the labor productivities of different periods, and (3) to discover the conditions necessary for the further increase of labor productivity.

In studying labor efficiency, attention must be paid to the accomplishment of individual workers. Model examples should be discovered and workers should be encouraged to follow and surpass these examples. However, the purpose of industrial statistics is to discover the average value of the productivity of a group (team, unit, workshop, plant, or industry) in a given period.

The level of labor productivity and its relationship with other figures are of great importance from the viewpoint of statistics. Labor productivity is often compared with a base which would be either the productivity of a past period or that in the original plan. It is also often compared with the productivity of a similar industry.

B. Time Unit in the Study of Labor Productivity

Labor productivity may be expressed as the amount of output produced by a unit of labor within a unit of time. Or, inversely, it may be expressed as the amount of time necessary for the production of a unit of the product.

Generally, the amount of output within a unit of time changes proportionally with labor productivity, and the amount of time necessary for the production of one unit of output changes inversely with labor productivity. To measure labor productivity in terms of output per unit of time is known as the direct method, while to measure it in terms of the amount of time necessary to produce one unit of output is called the inverse method. Both methods require the use of a time unit and an output unit.

More than one time unit is used for the computation of labor productivity. Some time units compute labor productivity in terms of man-hours, man-days, or number of workers on payroll per month, per season, or per year. Which of these time units should be used depends on the purpose of the study.

Labor productivity per man-hour reflects to a certain extent the actual working time. Thus it may be called the productivity with "pure working time." Man-day does not include pure working time alone. It includes also idle time. For this reason, labor productivity expressed in terms of man-days enables us to compare the possible effect of a longer or a shorter working day. Labor productivity per worker on the payroll per month reflects the effect of labor intensity for the month under investigation. The average monthly labor productivity is generally used as a norm for increasing production.

C. Productivity Indexes

Labor productivity may be expressed in terms of a particular commodity. However, there are very few industrial plants that produce only a single and homogeneous product. It is therefore necessary to use index numbers to indicate labor productivity.

The quantity of one product produced over a period of time cannot reflect the productivity of an industrial plant or workshop. We must resort to the use of a general indicator or an index, such as a standard output index, price index, or labor index.

1. Labor productivity in terms of output index -- The output index is a ratio of the output of a unit of labor in the reporting period to that in the base period. It is the reciprocal of the ratio of the amount of labor for one unit of product in the reporting period to that in the base period.

Such an output index can be used as a standard of comparison of the efficiency of several industrial plants engaged in producing the same commodity. The difference in productivity of two plants producing the same kind of goods may be attributed to technical conditions. Thus the output index reflects not only individual variations in output, buy also additional elements such as the technical conditions of the plants. The index number based on average ratios reflects the variation in productivity of individual plants and also the effect of structural changes in individual plants. Such an index is also known as a variable index.

An average number is affected by the individual values. It is affected also by the weights of the individual values. One special feature of the weighted index of labor productivity is that it eliminates the variations in the productivity of some plants. The nature of an averaged weighted index may be expressed mathematically as follows:

$$\frac{\sum \left(\frac{q_1}{T_1} : \frac{q_0}{T_0}\right) T_1}{\sum T_1}$$

The symbols q_1 and q_0 represent the outputs in the reporting and base periods, T_1 and T_0 the amounts of labor consumed in the reporting and base periods, and $\sum$ the summation.

Since the total amount of labor equals the amount of output times the amount of labor necessary for each unit of output, we may substitute q_0t_0 and q_1t_1 for T_0 and T_1 and let t_0 and t_1 represent the amount of labor necessary for one unit of product in the base and the reporting periods respectively. The formula above may then be written as:

$$\frac{\sum\left(\frac{q_1}{q_1t_1} : \frac{q_0}{q_0t_0}\right) q_1t_1}{\sum q_1t_1}$$

or in its simplified form: $\dfrac{\sum q_1t_0}{\sum q_1t_1}$

This means that the output index equals the total amount of labor having the productivity of the base period required for the production of the output in the reporting period, divided by the actual amount of labor necessary for the production.

2. Labor productivity expressed in monetary terms -- Output per unit of time is a direct indicator of the productivity of labor. However, this measure can apply only to industries that produce a single product. Labor productivity may be also expressed in monetary terms or as a price index.

The amount of output in the period under investigation may not truly represent the labor productivity of that period, since this output may be partly attributed to the labor productivity of a previous period. For example, an automobile plant produces in one month automobiles worth 2 million yuan. A large part of this value produced is accounted for by the productive effort of a preceding month. An overevaluation will result if output value is taken to represent labor productivity.

Pure physical output cannot adequately represent labor productivity because output is determined also by certain elements (the level of f. o. b. prices and of the prices of raw materials) which are not logically connected with industrial production.

The physical volume and not the monetary value of the raw materials consumed in a given period affect the level of labor productivity. Labor productivity in different industries varies according to the relative importance of the raw materials in the composition of the production value of the industries. Therefore, we cannot compare the labor productivity indifferent industries by using monetary terms. Marx said: "It is a stupid thing to compare the efficiency of different industries through the values of the commodities they produce." (History of the Theory of Surplus Value, Volume II, page 187).

The index of the value of labor productivity may be treated as a variable. First, we compute the total value of the output of each production unit (in terms of man-hours or man-days) in the base and reporting periods. Next, we compute the ratio of the value in the reporting period to that in the base period. The formula we use is:

$$\frac{\sum q_1 P}{\sum T_1} : \frac{\sum q_o P}{\sum T_o}$$

In this formula, q_o and q_1 represent the output in the base and the reporting periods, P the fixed price, and T_o and T_1 the amount of labor consumed in the base and reporting periods.

The method of computing labor productivity on the basis of price index or monetary value is as follows: First, we compute the values of the labor productivity of the particular industry in the base and reporting periods. We derive a set of ratios from these values and call them partial indexes. From these indexes we compute an arithmetic average, an average weighted by the numbers of workers in the reporting period. The formula is as follows:

$$\frac{\sum \left(\frac{q_1 P}{T_1} : \frac{q_o P}{T_o}\right) T_1}{\sum T_1}$$

Or, in simplified form:

$$\frac{q_1 P \frac{T_o}{\sum q_o P}}{\sum T_1}$$

3. Labor productivity index -- The labor productivity index is used when there is a number of products produced.

In computation, the amount of labor necessary for the production of each product should be multiplied by the quantity produced in the given period. If a comparison is to be made of the labor productivity for different periods, a single unit of the labor consumed in production should be used throughout the computation. The labor productivity index is a ratio of the average amount of labor consumed in a unit of time in the reporting period to the average amount of labor consumed per unit of time in the base period. The formula may be written as follows:

$$\frac{\sum q_1 t_{no}}{\sum q_1 t_1} : \frac{\sum q_o t_{no}}{\sum q_o t_o}$$

In this formula, q_1 and q_o represent the outputs of the reporting and base periods respectively, t_{no} represents the amount of labor necessary to carry out the production quota, and t_1 and t_o represent the amounts of labor actually spent in the reporting and base periods.

D. Some Remarks and Examples

Labor productivity varies with products, since the cost of raw materials, the proportion of the cost of raw materials to the total cost, and the relative importance of labor in the production vary from one industry to another. For instance, the productivity expressed in monetary terms in ironworks in generally higher than that in iron mines, since the price of pig iron includes the price of iron ore. The monetary productivity of the machine-building industry is higher than that of the ferrous metals industries, since the price of machines includes the price of ferrous metals. Productivity in light industry is higher than in heavy industry, because the value of raw materials (including, for instance, wool and flour) plays a greater part in the total cost than it does in heavy industry.

Thus, if labor is used more intensely in mining and other heavy industries, the average labor productivity will be lowered as the weight of low productivity increases proportionally in the total, although the labor productivity for each of these industries may rise.

This may be illustrated by the following example:

	Name of Product A	B	C	Total
	1949			
Total man-days	1,000	2,000	5,000	8,000
Labor productivity (Yuan per worker)	6,000	10,000	18,000	X
Output value (10,000 yuan)	600	2,000	9,000	11,600
	1950			
Total man-days	3,000	3,000	6,000	12,000
Labor productivity (Yuan per worker)	6,600	11,000	19,800	Y
Output value (10,000 yuan)	1,980	3,300	11,880	17,160

$$X = \frac{116,000,000}{8,000} = 14,500 \text{ (yuan per man-day)}$$

$$Y = \frac{171,000,000}{12,000} = 14,300 \text{ (yuan per man-day)}$$

From the values of X and Y, it seems that labor productivity in 1950 was lower than in 1949. But actually the former was 10 percent higher than the latter. It is incorrect to conclude that the labor productivity dropped 1.38 percent ($Z = \frac{Y - X}{X} = 1.38$ percent).

Use of an adequate formula to compute the growth of labor productivity is essential in industrial planning.

The percentage increase in labor productivity (Z) equals $\frac{T_{1949} - T_{1950}}{T_{1950}} \times 100\%$

In our above example, $T_{1949} = \frac{19,800,000}{6,000} + \frac{33,000,000}{10,000} + \frac{118,800,000}{18,000} =$

$3,300 + 3,300 + 6,600 = 13,200.$

$T_{1950} = 3,000 + 3,000 + 6,000 = 12,000.$

$$Z = \frac{T_{1949} - T_{1950}}{T_{1950}} = \frac{13,200 - 12,000}{12,000} \times 100\% = 10 \text{ percent}$$

This formula is adequate for comparing the labor productivity in different periods. However, it does not reflect the actual conditions as there are very few cases where an industry has only one product. This may be illustrated by the following two examples:

1. A textile plant employs 1,000 workers. It produced 10,000 bolts of coarse cloth in 1949 at a cost of 15.72 yuan per bolt, and 10,000 bolts of fine cloth in 1950 at a cost of 26.68 yuan per bolt.

The labor productivities for the 2 years are: for 1949, 10,000 times 15.72 divided by 1,000, or 157.20 yuan; for 1950, 10,000 times 26.68 divided by 1,000, or 266.80 yuan.

The productivity in 1950 seems to have risen 70 percent although the output for the 2 years is the same.

2. One dye-manufacturing plant employs 100 workers. It produced 100 tons of ammonium sulfide last month at a cost of 18,000 yuan per ton, and this month 80 tons of direct green dye at a cost of 100,000 yuan per ton. The labor productivities for these 2 months are: last month, 100 times 18,000 divided by 100, or 18,000 yuan; this month, 80 times 10,000 [sic] divided by 100, or 80,000 yuan.

Despite the output drop, the productivity this month shows an increase of 345 percent.

From these examples we may conclude that output figures are very important in industrial statistics. All the ratios should be studied along with the actual figures on industrial output.

To compile a labor productivity index on the basis of labor productivity is one of the important tasks of economic planning. In the study of labor productivity, our main interest may be in the ratio of current productivity to that in the base period, to planned productivity, or to the productivity of another industry.

In compiling a labor productivity index, the productivity of all workers is averaged. To introduce the productivity of technically advanced workers and use it as a model, it is necessary to treat the productivity of the advanced workers separately.

E. Conditions Necessary for Higher Productivity

The conditions under which a socialist enterprise improves its labor productivity are through higher production techniques, better operational organization, and higher educational and political levels of the workers.

A higher technical skill can be achieved by the use of machines and tools. Better machines and tools can increase the efficiency of the workers and save time.

Adequate organization is also important, for under the same technical limitations, the efficiency of the workers varies with the organization of labor and operations. The importance of proper organization may be illustrated by the following example:

Our example concerns the planning of production operations (more accurately, the distribution of production tasks to the workshops). If you assign a worker to finish work on ten parts before he is assigned to another job, you may as well order him to finish 100 parts. Either job requires the same amount of time for preparation and termination. Since one job involves ten machine parts while the other involves 100 parts, the preparation time needed for the 100 parts is proportionately, only 10 percent of that required for the 10 parts. This indicates that a worker produces much more under the specialization made possible by mass-production methods.

The size of an operation (small, large, or mass-production) and its organization greatly determine the level of productivity.

The division of labor and the layout and specifications of the workshops are the factors that determine productivity. Measures which simplify the operation and limit machines to specific uses may contribute a great deal to the increase of productivity.

Labor productivity is also determined to a great extent by plant layout and labor discipline. Proper organization of the production process, installation of safety devices, adequate illumination, and installation of necessary machines and tools are indispensable for increasing labor productivity.

High efficiency depends also on an uninterrupted supply of raw materials and semifinished products. Advance provision of tools and instructions, adequate guidance to workers, comfortable working conditions, and an incentive wage system are also essential for the increase of labor productivity.

Another factor that determines the level of labor productivity is the social and political level of the workers. In this connection, Marx listed the average skill of the workers as the first factor that determines labor efficiency. Under the same working conditions, a worker of high skill needs less time to perform a job than a less skillful worker. Therefore, to improve the skill of the workers is an important step towards higher labor productivity.

VI. WAGES AND THE PRODUCT OF LABOR -- A DISCUSSION OF THE WAGE SYSTEM IN THE SOVIET UNION

Wages are the main source of income of the worker. They affect the living standards of the worker and his dependents. They indirectly affect the level of national income and employment. There are two forms of wages, monetary and social.

Under the Soviet economic system, wages are a social product. Monetary wages are given to the worker for his own use and distributed to him according to the results of his labor (or, according to the amount and quality of his work). There is a social wage in addition to the monetary wage. On the basis of the wage theory of socialism, monetary wages and social wages, are part of real wages. Social wages include free education and hospitalization; social insurance, minimization of hazards and diseases, and provision of workers' living quarters, recreation facilities, and other welfare facilities. In the Soviet Union, social insurance is considered a social dividend. It is a principal form of social wages and an assurance of material welfare to the worker. A worker who wishes to receive more of what he produces must constantly improve his efficiency and increase production.

We shall limit our discussion to monetary wages. Although there are many forms of monetary wages, the most important are piece wages and time wages.

Under the time-wage system, a worker is paid according to the amount of time he works, or his wage rate times the amount of time he works. Time wages may be paid in a fixed amount or on the basis of an incentive wage scale. The fixed time-wage system provides a fixed salary for each type of work or job. Technical personnel and staff members are usually paid on a fixed-salary basis. The incentive-wage system utilizes output as another basis of wage payment and thus corrects the weakness of a straight time-wage system.

Under the piece-rate wage system, a worker is paid on the basis of his output. This is the principal wage system in the Soviet Union. It is used widely in the Soviet Union since it can stimulate production and help to fulfill various economic tasks.

Under the unlimited and straight piece-rate wage system, wages are equal to the standard piece rate times the quantity of work. The standard piece rate is based on the standard time and the wage grades.

Another form of piece-rate wage system which is not widely in use is the cumulative piece-rate wage system. A higher rate is paid on the amount of work exceeding a certain limit. The purpose of this system is to bring about the highest labor productivity. The additional wage necessary under this system is compensated for by the savings resulting from the system.

In practice, an incentive wage is paid to the worker under the piece-rate wage system. The worker receives regular piece-rate wages, but may receive a bonus for remarkable achievements in performance. For instance, a steel-mill worker may receive a bonus in addition to his regular piece-rate wages if he realizes a saving in electric consumption.

A. Application of the Two Wage Systems

On the basis of socialist wage principles, Stalin gave instructions that "an adequate wage system should distinguish the difference between skilled and unskilled labor and between strenuous and light work" (Problems of Leninism, 11th edition, page 335).

In the Soviet Union, the time-wage system is practiced only when the standard piece rate cannot be precisely determined. The time-wage rate varies with the types of products and the seniority of the worker. According to the experience of the Soviet Union, production can increase greatly if the time-wage system is replaced by a piece-rate system, other conditions remaining equal. On the other hand, the result is the reverse if a piece-rate system is replaced by a time-wage system. Under the time-wage system, a worker is paid on the basis of his length of service (years of continuous service) and his skill. Under such a system, there is no direct relation between wages and output. Consequently, it provides no incentive to the individual for the increase of production. Under the socialist economy, the time-wage system is not very popular. Some industries, however, are still using it because they cannot measure the work on a piece basis.

To increase the stimulating effect of the time-wage system, the Soviet Union incorporated into it an incentive element. The new system is known as the incentive time-wage system. Under this system, the wage of the worker is determined by the quality and quantity of his work instead by seniority or skill. As Voznesenskiy said: "To stimulate individual incentives through the joint use of a bonus system and a general wage system is the most effective way to increase production. Only on such a basis can the march of socialism be supported by the enthusiasm of millions and develop into a tremendous force" (Soviet Economy During the War of Defense, by Voznesenskiy, page 153).

Most of the executives (managers and chief engineers), engineers, technicians, and staff members are entitled to bonuses. If they can fulfill or exceed goals, lower the production cost, or improve the quality of the products, they receive a bonus according to the regulations. The size of the bonus varies with the relative importance of the industry among all the industries of the nation, the individual efforts contributing to the success, and the entent by which the actual cost is lower than the planned cost. A pure time-wage system exists only in very few industries. They are the petroleum, construction materials, and some machine-building industries.

The principal wage system in the Soviet Union is the straight and unlimited piece-rate wage system. A worker receives a standard wage for each unit of production he has completed. The more he produces, the more he receives. In some industries of vital importance, a cumulative wage rate is used. Sometimes a worker receives twice as much as the regular piece rate for each successive unit above the daily quota. For example, a worker is required to finish five units of products a day and is paid one ruble per unit of product. But he receives 2 or 3 rubles for each unit above the daily quota of five units. The time-wage system is used only in those industries where it is impossible to compute a standard rate for piecework. The universal adoption of the piecework system is in complete accord with the socialist principle, "to each according to his work."

The piece-rate wage system in the Soviet Union is an important device in increasing production and improving the living standards of the workers. It ties together patriotism (for instance, the increase in production) and self-interest (the increase of wages). A well-administered piece-rate wage system guarantees the quantity and quality of the products, improves labor organization and plant layout, and hastens the march of socialism and the Stakhanovite movement. The Soviet Union adopted a piece-rate wage system even before the War of Defense (1941). For instance, in 1938, 78 percent of all industrial workers in the USSR, 82.1 percent of the coal miners, and 74.4 percent of the ferrous metals workers received piece-rate wages.

B. Differential Wages

In the Soviet Union, the amount of wages received by the workers varies with the technical skill of the workers, the relative importance of the industry to the nation, and various local factors.

1. Technical Skill

Wage policy is an important economic instrument in a socialist country. It controls the manner in which labor is utilized. Workers who are skilled, are doing complicated work, or are experienced receive more wages than those who are unskilled, are doing simple jobs, or are inexperienced. A wage scale is established in which the workers doing the most strenuous work receive the highest rate and those doing light jobs receive the minimum rate. In some industries, the wage scale is determined by job classifications. The promotion of workers through recommendations and tests is the surest way to stimulate the initiative of the workers and thereby to increase productivity. As stipulated by the Central Committee of the Communist Party of the Soviet Union and the People's Soviet of the USSR, the wage rate of each worker is determined by examination.

The wage scale of the Stalin Automobile Plant in Moscow, as of September 1938, placed the workers into two categories: skilled workers and ordinary workers. The former includes workers who have gone through a rather long period of training. They are responsible for important operations such as supervision, production performance, and intraplant transportation. The latter includes workers responsible for the installation and repairing of machines, tools, and steam pipes. Each category consists of eight grades with the wage ratio between grades 1 and 8 being 1 to 2.5 for skilled workers and 1. to 3.5 for ordinary workers. The ratio of the wage for unskilled workers to that for skilled workers in coal mining is 1 to 2.2.

Under the regulations of the state, the salaries for leaders of enterprises (managers and chief engineers), technicians, scientific workers, and staff members are determined on the basis of their technical background, experience, knowledge, and other factors.

2. Relative Importance of the Industry

A socialist country may utilize the principle of value to encourage the labor force to work in key industries like the petroleum, coal, metallurgical, and machine-building industries. The government provides higher wages for these industries. This has stimulated the movement of workers into these industries. Such a tendency is even more obvious after monetary reform and the abolition of the rationing system.

Under the principle of "to each according to his work," a worker is paid not only in accordance with his ability, but also in accordance with the relative importance of his job and the working conditions. High wages therefore prevail in key industries and in strenuous and hazardous jobs. For instance, the government pays higher wages to drill, punch, or hammer operators, and to coal workers and miners. This is because coal mining is a key industry and is extremely hazardous.

3. Plant Location as a Factor in Wage Determination

Wage levels in the Soviet Union vary with the nature of the industry and geographical area. (See "Wage Determination in the Soviet Union", an article by Chu Tzu-shou in Chungkuo Kung-yeh (China Industry), Volume 1, No 9.) The purpose of wage differentiation according to geographical area is to obtain a balanced industrial development in the entire country. Thus wages are higher in areas of great economic importance and in remote frontier regions where workers are subject to severe weather conditions. During the last war, high wages were paid in western Siberia, the Urals, and the Volga Valley, where the defense industries were located.

In August 1946, the Council of Ministers USSR decided to increase the wages of workers and engineers in the Urals, Siberia, and the Far Eastern region and to build housing projects for them. The purpose of this decision was to improve the living conditions of the miners and petroleum and transportation workers and to attract more workers to these areas. The wage increase amounted to 20 percent.

C. Determination of Wage Rates and Schedule

In the Soviet Union, each worker has a fixed wage rate according to his ability, experience, job classification, and job responsibility. Workers doing strenuous work are placed in upper grades and receive higher wages. The wage rate for a skilled worker of the highest grade is sometimes 250 or 300 percent higher than that for an unskilled worker in the lowest grade. The actual wage received by a worker equals the fixed rate assigned to him times the quantity he produces. Since 90 percent of the workers in the Soviet Union can exceed their job quotas, the wages they receive are actually higher than the wages stipulated in the wage schedule.

Wage schedules vary with industries. But a wage schedule is always a part of the collective contract between the management and workers. Before the wage schedule is determined and entered into the collective contract, it is thoroughly discussed by the workers, approved by the union and management, and finally authorized by the authorities.

One of the important tasks for the workers' representatives in a plant is to determine the norms. Norms refer to the amount of output a worker should produce under normal conditions. The so-called normal conditions require: (1) adequate mechanical facilities, (2) uninterrupted supply of principal materials and tools, (3) good condition of raw materials and tools, and (4) safe and healthy working conditions. A worker who exceeds the norms receives a higher wage rate as a reward for his initiative.

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